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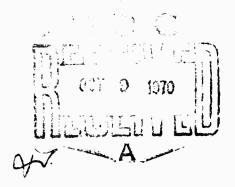
OF

THAW PENETRATION AND SUBSIDENCE RUNWAY AND TAXIWAY SECTIONS THULE AIR FORCE BASE

1953 & 1954 THAWING SEASONS



PREPARED BY



ARCTIC CONSTRUCTION AND FROST EFFECTS LABORATORY
NEW ENGLAND DIVISION
BOSTON, MASSACI: ETTS

FOR

OFFICE OF THE CHIEF OF ENGINEERS

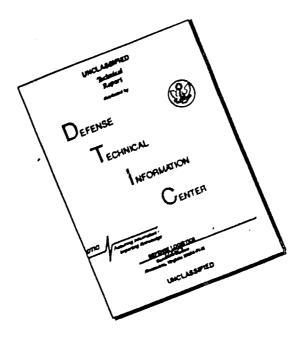
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JANUARY 1955

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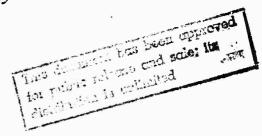


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SYNOPSIS

Construction of the runway at Thule Air Force Base, Greenland, began in the Summer of 1951. By the end of this first summer seven thousand feet of runway with a temporary surface of penetration macadam was operational. During the 1952 construction season the runway was extended to 10,000 feet and associated taxiway and aprons constructed. Hot mix asphalt paving was utilized in this construction and was also placed over the original penetration macadam runway pavement. The subsidence of certain runway pavement sections during the summer of 1952 resulted in the initiation of a program of field investigations at those locations. In the spring of 1953 a number of temperature and ground water wells, as well as vertical movement observation points, were installed under and adjacent to designated buildings, at Crescent Lake Dam, and at selected runway and taxiway locations. Observations were made at desired intervals throughout the 1953 and 1954 thawing seasons.

This report presents an analysis of the data obtained during the 1953 and 1954 thawing seasons at the runway and taxiway test installations. An analysis of the pavement subsidence, which occurred in two areas, is given and a correlation is made between subsidence, depth of thaw and the characteristics of the subgrade soils. The effect of pavement surface color is discussed and tentative conclusions are drawn. The existence of a seasonal ground water table is noted and explained.

Since in some areas the subgrade soils at Thule contain large masses of ice, distributed irregularly throughout the soil mantle and the melting of this ice results in irregular subsidence of the pavement

surface, pavement design at Thule should be based on preventing thaw from penetrating into high ice content subgrade soils after the paving materials have been placed. The data thus far obtained indicate that this may best be accomplished at Thule by providing an 8 foot minimum combined thickness of pavement and non-frost susceptible base above the subgrade soils.

In the present subsidence areas the combined thickness of pavement and base course material is in the range of approximately 4 feet to 6 feet. Analyses based on the amounts of pure ice and high ice content soils encountered in test pits in the area indicate that continued localized subsidence will occur at a diminishing rate for the next several thawing seasons and in some locations will continue for more than 20 years. A total future subsidence of 2.0 to 2.5 feet is expected at two of the explorations where high ice content subgrade conditions were revealed.

Recommendations for corrective measures in the areas of subsidence are given.

PART I - INTRODUCTION

- 1-01. AUTHORIZATION. An "Instructions & Outline for the Development of Design Criteria for Arctic Construction, Thule Air Force Base, Greenland" was prepared by the Chief of Engineers on 17 November 1952. The Permafrost Division, St. Paul District, was the original investigating agency. The Arctic Construction and Frost Offects Laboratory, Fire England Division, assumed these duties on 1 March 1953 by General Order No. 3, which stipulated transfer of all Permafrost Division functions and responsibilities from the jurisdiction of the District Engineer, St. Paul District, to the jurisdiction of the Division Engineer, New England Division.
- 1-02. FURFOSE AND SCOPE. The present investigational program at Thule Air Force Base is an outgrowth of a study by the Eastern Ocean District (formerly the Northeast District, East Ocean Division) of the runway pavement subsidence that occurred at two areas, each the full width of the runway and approximately 250 feet in length, during the 1952 thawing season. The program was broadened to include studies of other pavement areas and structures at Thule Air Force Base, with the objective of improving design criteria for airfield pavements, building foundations, and earth dams in arctic regions. As a result a number of temperature wells, ground water wells and vertical movement observation points were installed at selected locations so that fluctuations in ground temperatures and ground water as well as the vertical movement of structures and pavements could be observed.
- 1-03. ACKNO LEDG LITE. The investigational program was initiated by the Chief of Engineers in October 1952. The overall objectives and scope of the investigation were outlined at a conference held at the

Airfields Branch, Military Construction, Office of the Chief of Engineers, on 21 October 1952. This conference was attended by representatives of the Chief of Engineers, East Ocean Division, New England Division, Northeast District and the St. Paul District.

The detailed program was planned cooperatively between the former Permafrost Division, St. Paul District, the former Northeast District and the New England Division. The Permafrost Division designed, procured and shipped the observational equipment to Thule. North Atlantic Constructors performed the necessary test pitting, drilling and trenching operations required to install the thermocouple assemblies and ground water wells under the direction of the Northeast District. Representatives of the Architect-Engineer, Metcalf and Eddy, and Alfred Hopkins and Associates, installed the observational equipment, logged the test pits and borings and performed the necessary supplemental soil testing. During the initial stages of the field installation program, personnel of the Arctic Construction and Frost Effects Laboratory furnished technical assistance to the Northeast District. Following installation, periodic observations were made and will continue to be taken by representatives of the Architect-Engineer, and/or personnel of the Eastern Ocean District.

PART II - INVESTIGATIONS

2-01. GEYERAL. Installation of temperature wells in the pavement areas was commenced on 20 March 1953 and completed on 8 May 1953. The installation of the ground water wells was completed on 6 July 1953.

Twelve temperature wells, TR-1 through TR-12, were installed at the runway locations shown on Plate 1, to depths of 15 to 24 feet, depending on the thickness of fill. These wells were installed in pairs spaced 13 feet apart and a ground water well was drilled midway between each pair. Locations were chosen so that representative sections through varying thickness of fill could be observed and compared. Three additional ground water wells were drilled in the subsidence area between Stations 57+00 and 60+00.

In an effort to compare them progression beneath black and white pavement surfaces, a 125 foot long portion of the south taxiway was painted white. Two temperature wells, TTW-1 and TTW-2, were placed in the white-surfaced area and two temperature wells, TTB-1 and TTB-2, were placed in the adjacent unpainted area of the pavement. Vertical movement grids, as shown on Plate 2, were established at all runway and taxiway locations.

Initial readings of all runway temperature assemblies were taken on 8 May 1953 and of all taxiway temperature assemblies on 9 May 1953 and have continued at weekly intervals. Ground water observations in 1953 began on 6 July and in 1954 on 31 July and were continued at weekly intervals throughout the thawing seasons. Observations of vertical movements have been made at monthly intervals beginning with the initial readings on 14 June 1953, except for the months December 1953 through April 1954 and June and September 1954.

2-02. CLIMATIC DATA. Plate 3 presents a plot of average daily air temperatures taken from Weather Bureau records for 1953 and 1954, from 23 April through 30 September, together with curves of cumulative degree days (°F) of thaw as computed from these average daily air temperatures for the two years. Plate 4 presents cumulative freezing and thawing curves, starting with 1946-1947 freezing season, except for freezing seasons 1950-1951, 1951-1952 and the 1951 thawing season, for which temperature data are not available. Curve for the 1948-1949 thawing season also is not presented. Weather Bureau records show a mean annual temperature for the period 1946-1949 of \$12°F. The curves in Plate 4 illustrate the relative severities of the thawing and freezing seasons. Average values for 30 June, 31 July and end of thawing season, for the available years of record, are given below.

. <u>Date</u>	Cumulative Degree Days of Thaw	
70. 5	300	
30 June	120	
31 July	400	
End of Thew (on or about 14 Sept.)	650	

2-03. SCILS DATA. The subgrade soil at Thule is predominantly a glacial till and is classified as a silty, sandy gravel or a silty gravelly sand with 10 to 45 per cent of grains by weight finer than the 200 mesh. The bedrock is a diorite and, in the runway section at least, is relatively shallow varying from 10 to 15 feet below original ground surface. Ice is present in the subgrade soils in large amounts and is found as wedges, lenses, coatings on grains and as irregular masses up to 1.8 feet in thickness. For an example of the massive ice encountered see log of Test Pit S-716, Plate 5 and log of TR-5, Plate A9.

base course materials vary from poorly graded sandy-gravels and gravelly-sands to quarry rock. Logs of explorations at each temperature well in the runway and taxiway locations are included in Appendix A of this report.

All temperature wells were drilled by the North Atlantic Constructors using a "Joy Heavy Duty Champion", rotary drill. A special carbaloy bit fabricated in the field by the contractor's personnel proved very satisfactory in obtaining frozen core samples of the subgrade soil, except in instances where the subgrade contained a high percentage of large stones. In fill sections where relatively dry frozen granular soils predominated, a 6-3/4" Hughes Tricone Rotary Bit was used. The cuttings from this bit, blown to the surface by compressed air, were collected and the water content determined.

8 to 12 feet and at two taxiway locations to a depth of 8 feet. Logs of these explorations are included in Appendix A. The water contents of frozen chunk samples obtained from the test pits were compared with the water contents of the cuttings obtained from the drill holes adjacent to each test pit. The results of this correlation indicated that the water contents, as obtained from the cuttings, gave a reliable determination of the actual water contents of the soils encountered.

2-04. AS-BUILT PAVELENT SECTION. To protect subgrade soils from them penetration, the pavement design called for a minimum of 6 feet of non-frost susceptible base and subbase materials. There the difference in elevation between existing ground surface and proposed finished grade exceeded 6 feet, granular or quarry rock fill was placed directly on the

natural ground surface; otherwise the subgrade soil was stripped and excavated to produce the required 6-ft. base thickness. The deepest out, about 13 feet at one location, occurred between Stations 57/00 and 74/00. Plate 1 shows a centerline profile through this cut with an exaggerated vertical scale. All other cuts were relatively shallow.

A generalized cross section of the runway pavement is shown on Plate 6. The original design called for a uniform transverse slope of 1.5 per cent for the full width of the runway. After base course materials had been placed it was decided to construct the pavement with a 1.5 per cent slope on each side of a centerline crown. The crown was formed by stripping base course material from the high side of the slope (south side of runway). This operation reduced the original 6 feet of pavement and base to a minimum of approximately 3 feet at the south edge of pavement. Pronounced subsidence occurred along this edge of the pavement during the summer of 1952. To prevent further subsidence, a 25 foot box was excavated to a minimum depth of 6 feet along this edge from Station 61/00 to Station 75/00 and material replaced with non-frost susceptible fill (see Plate 6).

In the subsidence areas, between Stations 57/00 and 60/00 and between Stations 71/00 and 71/00, resurfacing operations to bring the pavement back to grade have resulted in a thickened surface course. In certain areas the bituminous concrete is now over a foot in thickness.

2-05. SUBSURFACE TE PERATURES. The progress of them below the surface, represented by the 0°C. isotherm and based on subsurface temperatures observed during the 1953 and 1954 thaving seasons at all runway locations, is shown on Plates 7 through 12. Similar temperature plots

of the taxiway assemblies are shown on Plates 13 and 14. A summar; of thaw and subsidence data at all runway and taxiway installations is given in Table 1. The depth of the 0°C. temperature was interpolated from the geothermal gradients drawn for successive observations. The position of the 0°C. isotherm is assumed to be the boundary between unfrozen and frozen soil. However, it is visualized that the actual boundary between frozen and unfrozen soil as it occurs in nature is a diffuse zone rather than a well defined plane at the interface of frozen and unfrozen soil. Subsurface temperatures obtained by means of thermocouples spaced at intervals of depth in the soil do not clearly define the limits of this zone either during the freezing or thawing cycles.

During the freezing cycle an essentially isothermal zone where a mixture of thawed and frozen soil exists together has been inferred. This inference is based on the shape of temperature-time curves drawn for various specific depths during the period of freeze back. These curves exhibit a marked flattening of slope close to 0°C. and in the vicinity of the maximum depth of thaw. At this depth, based on the thermocouple readings the ground temperature appears to remain constant, for periods ranging from one to three weeks. This essentially isothermal zone is indicated by shading in Plates 7 through 1h.

Examination of Plates 7 through 14 also indicates that some small amount of freezing occurs up from the bottom of the thawed zone due to the flow of heat to the underlying frozen soil which exists at several degrees below 0°C. This trend has not generally appeared in available subsurface temperature observations from more southerly arctic and subarctic installations, apparently because the temperature of the underlying permafrost in such areas has been much closer to below 0°C.

TABLE 1

SU MARY OF THAT AND SUBSIDENCE DATA FOR 1953 AND 1954 THATHIG SEASONS

THULE AIR FORCE BASE

	Hole	Station	Pepth of Fill in Fest	in F	-		msured e in Feet 5/22/54-8/24/54
	TR-1	25/00	13	7.7	7•7	0.01	C•Of
	TR-2	25/13	13	7.4	7.7	.	-
	TR-3	31.700	8.3	6.5	6.8	0.02	0.08
	TR-1		8.5	6.7	7.0	•	•
	TR-5	50/00	5.3	a 5.8	7.1	b 0.16	0.16
Runway	TR-6	58-1 3	5.6	a 6.li		•	-
•	TR-7	69/00	5.7	6.0	6.3	0.01	0.02
	TR-ô	69/13	5.7	6.8	7.2	•	•
	TR-9	91/00	9.0	7•7	3.0	0.00	0.00
	TR-10		9.0	7.4	7.7	•	•
	TR-11	93/50	10.5	6.9		0.00	0.00
	TR-12	97/63	15.0	6.L	6.7	•	
	TT:-1		9.0/	ó . 0	5 . 4	0.00	0.62
South	TT:2	91.775	9.07	5.8	5.5	•	•
Loop	TTB-1		9.0/	7.8	7.0	0.00	0.02
Taxiva	yTTB-2		9.0%	8.2	7.4	-	

*Fon-frost-susceptible

Notes:

- a. Before addition of 6" tituminous at this location during September 1953, making pavement thickness 1'-2".
- b. For period 14 June to 17 August 1953 only.

 Does not include unknown amount of settlement which may have occured between 17 August and 11 September 1953 when new settlement points were established at this location.

In general, thawing commenced beneath the runway pavement surface around the first week in May in 1953 and toward mid-May in 1954, and refreeze began around 14 September in both years, indicating a thawing period of approximately four months. The entire active some had cooled to freezing temperatures before 25 September. Thaw penetration in thick base course sections, on the runway, ranged from 6.4 feet to 7.7 feet in 1953 and from 6.7 feet to 8.0 feet in 1954. While it is logical to attribute the variations in thaw depth to local differences in density and water content a correlation of these data did not reveal a consistent relation—ship. At runway locations with lesser base thicknesses, notably at Station 58+00, 50 feet left of centerline and Station 69+00, 50 feet left of centerline where thaw has penetrated to the subgrade, the maximum depth of thaw has been markedly reduced. This is due principally to the high ice content of the subgrade soils.

At the taxiway locations, notable reduction in the depth of thaw beneath the white-surfaced area was observed. The maximum depth of thaw beneath the white-surfaced pavement averaged 5.9 feet in 1953 and 5.45 feet in 1954, as compared to 8 feet in 1953 and 7.2 feet in 1954 beneath the natural unpainted surface. Surface temperatures in the white surface averaged about 5°C. lower throughout the thawing season than those in the black. In mid-summer the difference was 2 or 3 degrees higher than this average value.

2-06. GROUND WATER (RUNWAY). A free water table had developed above the level of frozen ground by 18 July in 1953 and by 31 July in 1954 between Stations 57+00 75 feet L and 69+00, 50 feet L. The observations from the ground water wells between TR-5 and 6 and TR-7 and 8 are plotted with the temperature data on Plates 9 and 10. In general, the ground

water levels in all wells observed in the subgrade cut area rose a maximum of approximately one foot during the thawing season. It is in this cut area, from Stations 57+00 to 60+00, that thawing progressed through the fill material and penetrated the subgrade soil. The rise in water level in the base, as indicated from the ground water wells is believed to be primarily due to the melting of the high ice content soils in the subgrade.

2-07. PAVE TENT SUBSIDENCE. The subsidence during and prior to the 1953 and 1954 thawing season was confined to two areas between Runway Etations 57+00 and 60+00 and between Stations 71+00 and 74+00. These two areas lie at each end of the area of subgrade out which extends from approximately Stations 55+00 to 74+00. Average subsidence of the remainder of the runway pavement during the 1953 and 1954 thawing seasons was negligible. Plate 1 shows in plan the areas of subsidence and the limits of the cut. Plate 1 also includes a centerline profile showing the level of original ground, top of as-built pavement and bottom of cut.

Vertical movement grids, each covering a small area in the immediate vicinity of each pair of temperature wells, were established in the runway and taxiway, as shown on Plate 2. Initial vertical movement observations on these grids were taken on 14 June 1953. With the exception of the grid around TR-5 and TR-6, settlement of the grid points at all runway and taxiway temperature well locations during the 1953 thawing season was regligible (maximum subsidence 0.02 feet, with an average of 0.003 feet for seven locations). During the 1954 thawing season the vertical movement observations indicate that subsidence averaging as much as 0.05 feet may have taken place in the vicinity of TR-1,

TR-3, TR-7 and at the temperature well locations on the South Loop Taxiway. Since observations were not made on the settlement points during September (end of thawing, about 15 September), a more accurate appraisal of possible subsidence cannot be made.

The measured pavement subsidences and heaves in the vicinity of TR-5 and TR-6 are shown in Table 2. The measured maximum subsidence around TR-5 and TR-6 during 1953 was 0.16 feet with an average of 0.13 feet. However, since the pavement at this location was resurfaced to original grade on or about 17 August 1953 and new settlement points were not established until about 11 September, the values of subsidence given in Table 2 are for the period 14 June to 17 August 1953 only. On the basis of the remaining degree-days of thaw after 17 August and the resulting increase in them penetration after this date, it is estimated that an additional subsidence of about 0.05 feet could have occurred, for a total seasonal subsidence of about 0.18 feet.

During 1954, the measured maximum subsidence around TR-5 and TR-6 was 0.16 feet with an average of 0.13 feet for the period 22 May to 25 August 1954. The next set of observations was made on 16 October and shows a maximum subsidence of 0.19 feet with an average of 0.16 feet in relation to observations made on 22 May. Thaw reached a maximum on or about 14 September and complete refreeze of the base and subgrade materials had occurred prior to 10 October. If the values given for pavement heave in Table 2 for 11 September to 25 November 1953 may be considered representative of the amount of heaving due to freezing which occurred during fall of 1954, the subsidence around temperature wells TR-5 and TR-6 is estimated to have averaged about 0.21 feet for the

TABLE 2
VERTICAL MOVEMENT OF PAVEMENT
AROUND TEMPERATURE WELLS TR-5 AND TR-6

PT. NO.*	SUBSIDENCE (ft.) 14 June to 17 Aug. 1953	HEAVE (ft.) 11 Sep. to 25 Nov. 1953	SUBSIDENCE (ft.) 22 May to 25 Aug. 1954
1	0.11	0.06	0.11
2	0.13	0.06	0.13
2 3	0.14	0.06	0.16
4	0.12	0.06	0.16
4 5 6	0.12	o . 06	0.09
6	0.13	0.06	0.11
7	0.10	0.06	0.12
8	0.13	0.06	0.11
9	0.12	0.06	0.16
10	0.13	0.07	0.14
11	0.13	0.06	0.09
12	0.16	0.06	0.15

^{*}Location of grid points is shown on Plate 2.

summer of 1954. This value added to the average subsidence estimated as occurring in 1953 gives an estimated two-year average subsidence (less the heave in the fall of 1953) at this location of about 0.33 feet.

Figure 1 below illustrates graphically the average movement of the 12-point grid around temperature Wells TR-5 and TR-6 for the period 14 June 1953 through 16 October 1954. The initial level points were established on 14 June 1953 at which time the average depth of thaw at TR-5 and TR-6 was 4 feet. The total thickness of pavement and base at this location averages 5.5 feet.

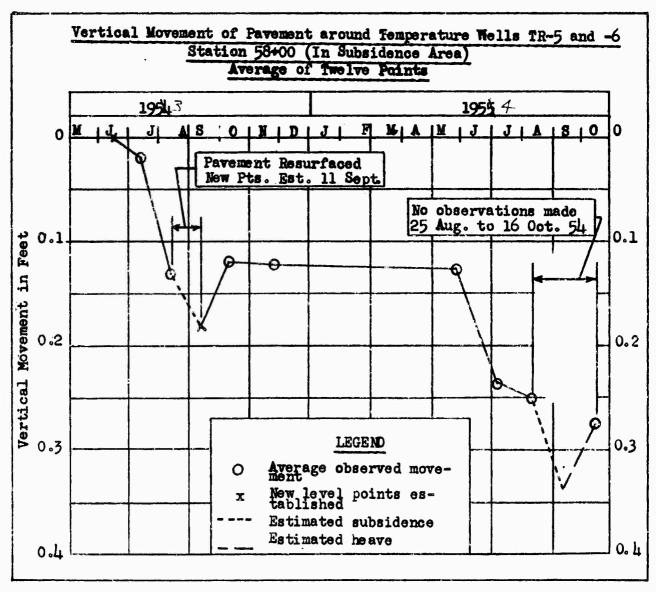


Figure 1

Around TR-7 and TR-8, the maximum subsidence shown by the grid pointswas 0.01 feet during 1953 and 0.02 feet in 1954. This pair of temperature wells, although located well within the area of subgrade cut, was not positioned in an area of previous subsidence as were wells TR-5 and TR-6. These two pairs of wells were located to investigate the reasons for the localization of subsidence in certain sections of the subgrade cut rather than its general occurrence throughout the area. Reference to the boring logs of the test pits at these two runway locations, Plates A-27 and A-28, indicates the subgrade soil at the location of TR-7 and TR-8 contains only minor ice segregation as compared to the subgrade soils at TR-5 and TR-6. In addition the water content of the base course material around TR-7 and TR-8 is somewhat higher than at TR-5 and TR-6, which would tend to reduce the depth of subgrade thew at this location.

along the entire length of the runway. Points were spaced at 100-foot intervals along the runway centerline and at 50 feet and 90 feet right and left of the 100-foot interval points in the subgrade cut section between Sta. 57+00 and Sta. 74+00. The total vertical movements between 9 May 1953 and 5 September 1953, and between 9 May 1953 and 19 September 1954, of the points located in this cut section is given in Table 3.

Both above-described sets of grids have shortcomings. In the local grids around the temperature wells, the area covered is only a small part of the total subsidence area, while the grid covering the length of the runway has too great an interval between points. Data from observations of these two grid systems indicate a maximum subsidence of only

0.18 feet during 1953 whereas an average of 0.25 feet of bituminous concrete was required during resurfacing operations in 1953 to bring the subsided areas back to grade. Personnel at the site during the summer of 1953 have indicated, based on the unevenness of the pavement surface, that localized subsidences occurred which were greater than values measured at the grid points.

TABLE 3

VERTICAL MOVEMENT OF RUNWAY PAVEMENT IN SUBGRADE CUT SECTIONS THAM SEASONS 1953 AND 1954

901L 5-9-53 3 to 9-9-54	i i i i i i i i i i i i i i i i i i i
5-9-53 to 9-5-5	28242322222233344438
501 <u>L</u> 5-9-53 3 to 9-19-54	## of re- ***********************************
5-9-53 to 9-5-5	01 02 03 04 01 01 01 02 02 03 03 04 04 01 01 01 01 02 03 03 03 03 03 03 03
9018 5-9-53 53 to 9-19-54	##Govement at t period 9 May surfacing on
5-7-53 to 9-5-	20000000000000000000000000000000000000
50 1R 5-9-53 3 to 9-19-54	44444444444444444444444444444444444444
5-9-53 to 9-5-5	6.999999999999999999999999999999999999
5-9-53 to 9-19-54	4.01 6.01 6.02 6.02 6.02 6.02 7.03 7.03
\$\frac{\beta}{5-9-53} \frac{5-9}{5-9} \tag{to \$-5-53 to}	01 .00 .00 .00 .02 .02 .02 .03 .00 .00 .00 .00 .00 .00 .00 .00 .00
Runway Centerline Stationing	(1) (2) (3) (4) (5) (5) (5) (5) (5) (5) (5) (5) (5) (5

16

PART III - AMLYSIS OF DATA

3-01. THAN PENSTRATION AND SUBSIDENCE. The maximum depth of thaw under natural colored asphalt pavement sections, where the base course thickness was greater than the thaw depth, ranged from 6.4 feet to 8.2 feet in 1953 and from 6.7 feet to 8.0 feet in 1954. In general the least thaw penetration occurred at locations where the base course contained the greatest amount of water per unit volume with the thaw penetration increasing at locations with less moisture in the base.

In cut sections the total thickness of base course material is 6 feet or less and seasonal thawing of the subgrade occurs. In these sections, thaw progresses at about the same rate as in the deeper fill areas until it reaches the subgrade. At this point, as Plates 7 through 10 indicate, the rate of thaw penetration noticeably lessens. Test pits in the cut area have shown the subgrade to contain large amounts of ice in the form of lenses, pockets, coatings on grains and irregular masses. The substantial amount of heat required to melt this ice is the reason for the reduced rate of subgrade thaw penetration.

The presence of ice in a soil in excess of that required to fill the natural voids results in the separation of a certain number of the individual soil grains. This separation of particles may be the result of ice lenses and coatings barely discernible to the eye or may result from formation of substantial ice layers and masses. If soil containing such segregated ice is melted, thus restoring the intergranular contacts, vertical subsidence will occur. This is the nature of the settlement taking place in portions of the area of subgrade cut on the Thule runway.

It is possible to estimate the amount of future subsidence that may be expected at a given location if the properties of the underlying soil are known. The relationship between the vertical subsidence, the void ratios of the frozen and thawed soils and the depth of thaw in the frozen soil is shown in the following formula -

$$S = \frac{e_{f} - e_{t}}{1 + e_{f}} \cdot H$$

Where S = estimated vertical subsidence in feet resulting

from thawing a frozen soil layer of thickness (H)

in feet.

e, = average void ratio of the frozen soil layer.

• t = estimated average void ratio of the soil layer after thawing and consolidation.

The void ratio of the frozen soil may be determined using undisturbed frozen soil specimens obtained from test pits or borings. The depth of thaw (H) may be calculated using the equation given in the following paragraph. It is necessary to predict the void ratio of the soil after thawing and consolidation. An estimate of this latter void ratio can be made by utilizing soil density data for thawed soil, existing in the area under approximately the same overburden, of classification and gradation similar to that of the frozen soil.

The depth of thaw penetration into a frozen subgrade soil may be computed by the following formula* -

^{*}Corps of Engineers, Engineering Manual - Military Construction Part XV, Arctic and Subarctic Construction; Chapter 6, Calculation Methods for Determination of Depths of Freeze and Thaw in Soils (Draft) May 1954.

$$H = \sqrt{k^2 \left[R^2 + \frac{48kIp}{L}\right]^2 - k \left[R\right]}$$

where

H = depth of thew penetration into a frozen subgrade in feet. (Note that H is not depth of thew penetration from pavement surface).

- k = arithmetic mean of the thermal conductivities of the frozen soil (k_g) and the thawed soil (k_u) in Btu/hr./sq. ft./ ^{O}F ./ft.
- R = thermal resistance of the thawed soil above the frozen subgrade layer, at time (t), Hr-sq.ft.-OF./Btu.
 - L = latent heat of the frozen subgrade = 1.ll x dry unit
 weight of soil x water content in per cent, Btu/cu.ft.
 - Ip partial thawing index remaining to thaw the subgrade at time (t). (Surface thawing index for entire thawing season minus portion of surface thawing index expended in thawing the soil overlying frozen subgrade layer), deg-days.

By means of the two foregoing equations the depth of thaw penetration during a thawing season and surface subsidence resulting from thawing a frozen soil layer of known ice content may be estimated for one or a series of thawing seasons.

^{*} First Interim Report, Analytical Studies of Freezing and Thawing of Soils by H. P. Aldrich, Jr. and H. M. Paynter, dated June 1953. Prepared under contract with Arctic Construction and Frost Effects Laboratory.

appreciable shange in soil gradation represents the boundary between the previously unthawed subgrade and the subgrade thawed during the 1952 summer season.

Referring to Plate 15, a total subsidence of 1.63 feet in 20 years is predicted for the soil sequence shown, 0.2 feet of this cumulative total occurring during the 1954 thawing season, 0.18 feet during the 1955 thawing season, and continued subsidence occurring at progressively smaller increments during subsequent thawing seasons. Subsidence will continue until the combined affect of adding pavement to surface and/or a sufficient thickness of thawed and consolidated soil has accumulated, over the high ice content subgrade, to confine maximum seasonal thawing within this accumulated previously thawed soil layer which is relatively free of segregated ice.

as subsidence occurs and the subgrade conditions are as depicted on Plate 15, further thawing and subsidence will theoretically be arrested after 0.5 feet of thawed and consolidated subgrade soil has accumulated and 0.7 feet of additional bituminous surfacing has been added to keep the pavement at grade. A stable condition would be approached over a period of several years at a progressively decreasing rate. Assuming for purposes of analysis that surfacing is not added to keep the pavement level and subgrade conditions are as shown in Plate 15, calculations indicate that thawing would continue until a total pavement subsidence of 1.9 feet occurred, and 1.0 feet of thawed and consolidated soil had been built up. The following table is presented as an example of the slow rate of cumulative increase of such a soil layer. The water contents shown are actual values as observed in runway test pits.

Water Content % Dry Wt.	Yold Retio Frosen Subgrade	Assumed Void Ratio After Thew and Consolidation	Resulting thickness (inches) of thewed and consolidated soil for each one inch of subgrade soil melted
95	2.8	0.25	0 mp
30û	8.9	0.25	0.14
300 962	28.6	0.25	0.04

Thus, for a frozen ice-soil mixture having a water content of 300 per cent, each one inch of thaw results in an increase of only 0.14 inch of thawed and consolidated material. To build up the one foot layer of soil necessary to arrest additional thaw penetration into the high ice content material would require thawing approximately 7 feet of subgrade soil. Since the theoretical thaw penetration into the subgrade is in the order of 2 to 3 inches and this rate will continually decrease as the years progress, it may be seen that subsidence in a section where the subgrade soils have water contents of the order of 300 per cent would continue for several years. Where previously unthawed subgrade soil does not contain considerable segregated ice, the seasonal thawing during the next few years will, by thawing and consolidation, tend to build up a sufficient thickness of subgrade free of segregated ice to prevent further degradation and subsidence.

the highest ice content or lowest soil content subgrade conditions of any of the explorations. Assuming the water contents shown (318 and 962 per cent) are representative of the two layers at subgrade, only about 3-inches of soil will accumulate by thawing from 4.6 foot depth to 7.5 foot depth. The pavement subsidence resulting from such thawing would occur over a period of several years and would total approximately 2.7 feet. Since

the test pit was not of sufficient depth to determine the thickness of the lower ice layer an unknown amount of additional subsidence is possible at this location.

Because of the irregular nature of the distribution and quantity of subgrade ice, it is not known whether Test Pit S-716 reveals an extreme condition or whether similar conditions exist at other locations within the subsidence area. It is believed logical to assume that there are at least a few areas where the subgrade conditions are as severe as at Test Pit S-716. In such areas, subsidence must be anticipated to continue at a rate of 1-1/2 to 2 inches for each of the next several thawing seasons. Resurfacing to keep the pavement level in areas of considerable subsidence may, after a period of years, result in sufficient increase in the thermal resistance of the pavement and base to prevent further subgrade thawing. Theoretically a pavement thickness of 2.5 feet over 5 feet of gravel base of the type used at Thule will protect the subgrade from thawing. For conditions at Test Pit S-716 where the base is 4.6 feet, the required asphaltic pavement thickness to arrest thawing would be approximately 3.0 feet. Since the annual accumulation of subgrade soil by thawing will be negligible at this location, the thermal resistance of the resurfacing material must play a major role in arresting future thawing and subsidence.

3-02. PAVENETH HEAVE. As shown in Table 2, the measured pavement heave resulting from refreezing of the base and subgrade materials in the area of subsidence in the vicinity of TR-5 and TR-6 averaged 0.06 feet. The pavement heave indicated elsewhere in the subsidence area was of similar magnitude. Although some of the water released by thawing

probably drained away before refreezing started, the distinct water table existing in this area throughout the summer undoubtedly resulted in increased moisture availability and increased heave on freeze-up in the fall.

3-03. SURFACE COLOR. Plates 13 and 14 show that the depth of thaw beneath the white painted surface is significantly less than that beneath the adjacent natural colored asphaltic concrete surface. The fact that pavements in arctic regions receive solar radiation 24 hours a day during the summer months coupled with the much lower absorptivity of the white-colored surface has resulted in surface temperatures in the painted pavement averaging about 5°C lower than those in the adjacent unpainted pavement. The net effect of this lowered surface temperature is a marked reduction in total heat transfer between the pavement and the underlying soils and a corresponding reduction in the maximum thaw depth.

The surface around TTW-1 was painted white on 9 May 1953. At this time that had penetrated to about 0.7 feet below the top of the pavement. It is of interest to note that this 0.7 feet had completely refrozen by 14 May and rethaming did not commence again until 1 June. Them beneath the adjacent unpainted surfaces continued to progress uniformly throughout this period.

During the spring of 1954, the presence of a layer of compact snow up to two inches in thickness on the pavement surface in the vicinity of the taxiway temperature installations resulted in delaying penetration of the thaw beneath the surface until the snow disappeared on about 22 May. Thaw beneath both the white-painted and natural surfaces began on this date.

Referring to Plates 13 and 14, it will be noted that from 22 May to 9

June 1954 thaw penetrated almost three feet below the natural asphaltic concrete surface as compared to less than 1.5 feet below the white-painted surface.

The effect of surface color on rate and total depth of thaw was about the same for both the 1953 and 1954 thawing seasons. The greater depth of thaw penetration under TTB-1 and -2 and TT -1 and -2 during 1953, despite the greater thawing index of 1954, is attributed to introduction of heat into the ground by excavations made on approximately 4 July 1953 when all four thermocouple strings were removed and re-installed so as to move terminal boxes from one side of the taxiway to the other. The depths of thaw in 1954 are therefore considered more nearly representative.

3-04. GROUPD WATER. The existence of a ground water table in the cut section between Sta. 57+00, 75 feet left, and Sta. 69+00, 50 feet left, during the latter half of the thawing season is believed to be due to the melting of the ice in the subgrade soils. Its appearance in the second half of July coincides approximately with the penetration of thaw into the subgrade. As them began melting the ice in the top layer of the subgrade, the ground water table rose rapidly to a level 1/2 to 2-1/2 feet above the level of frozen ground. Here an equilibrium between the supply of water due to continued melting and the loss of water due to drainage was apparently established. The volumetric heat capacity of the newly released water may have exerted some control by reducing the potential rate of melting of the underlying still-frozen soil. At TR-5 and TR-6 the water

table remained relatively constant with only minor fluctuations until early September, when some lowering of the table began. This lowering of the water table paralleled closely the decreasing rate of them penetration and consequent decrease in the rate of supply of water. At TR-7 and TR-8 the water table held a fairly steady level, or dropped slightly, from lete July until freeze-up.

PART IV - SUMMARY OF RESULTS AND CONCLUSIONS

- 4-C1. SUMMARY OF RESULTS AND CONCLUSIONS. Based on the foregoing analysis of the observational data obtained at the test areas on the runway and south loop taxiway at Thule AFB during the 1953 and 1954 thawing seasons* the following conclusions are reached:
- a. Where the total the kness of pavement and base course exceeded the depth of thaw, the maximum depth of thaw penetration beneath the natural color asphalt pavement at six runway temperature well locations averaged 7.1 feet and ranged from 6.4 feet to 7.7 feet during 1953, and averaged 7.4 feet and ranged from 6.7 to 8.0 feet in 1954. For similar conditions on the south loop taxiway, observations in 1953 showed an average maximum them penetration at two locations under natural color asphalt pavement of 8.0 feet and a corresponding average value for two locations under pavement painted white of 5.9 feet; in 1954 average maximum depths of thaw for these locations were 7.2 feet for black pavement and 5.45 feet for white pavement. The 1954 taxiway observations are considered probably more representative than the 1953 values because of disturbance of the thermocouple installations during the summer of 1953; however, the 1954 values may also be smaller because a layer of snow remained on the taxiway during approximately 3 weeks in May 1954, delaying thaw, whereas the pavement was bare in the same period in 1954.
- b. Fave ent subsidence was confined to two areas, each approximately 200 feet in length, lying at either end of the area of subgrade cut, which extends from approximately Sta. 55+00 to Sta. 74+00 and has thicknesses of pavement and base course less than the depth of seasonal thawing.

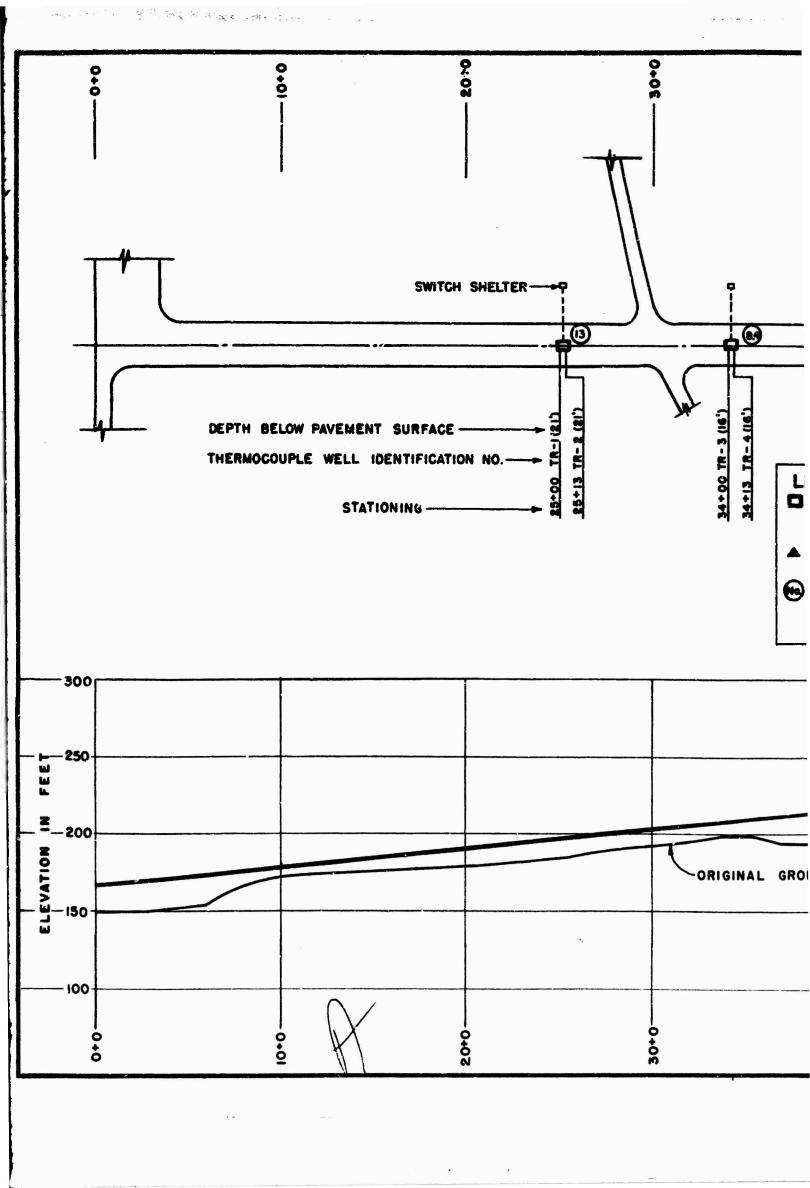
^{*}The Air Thawing Index during 1954 was the maximum value for the six years of temperature record available, and 20 per cent greater than the mean value. During 1953, the Index was equal to the mean value.

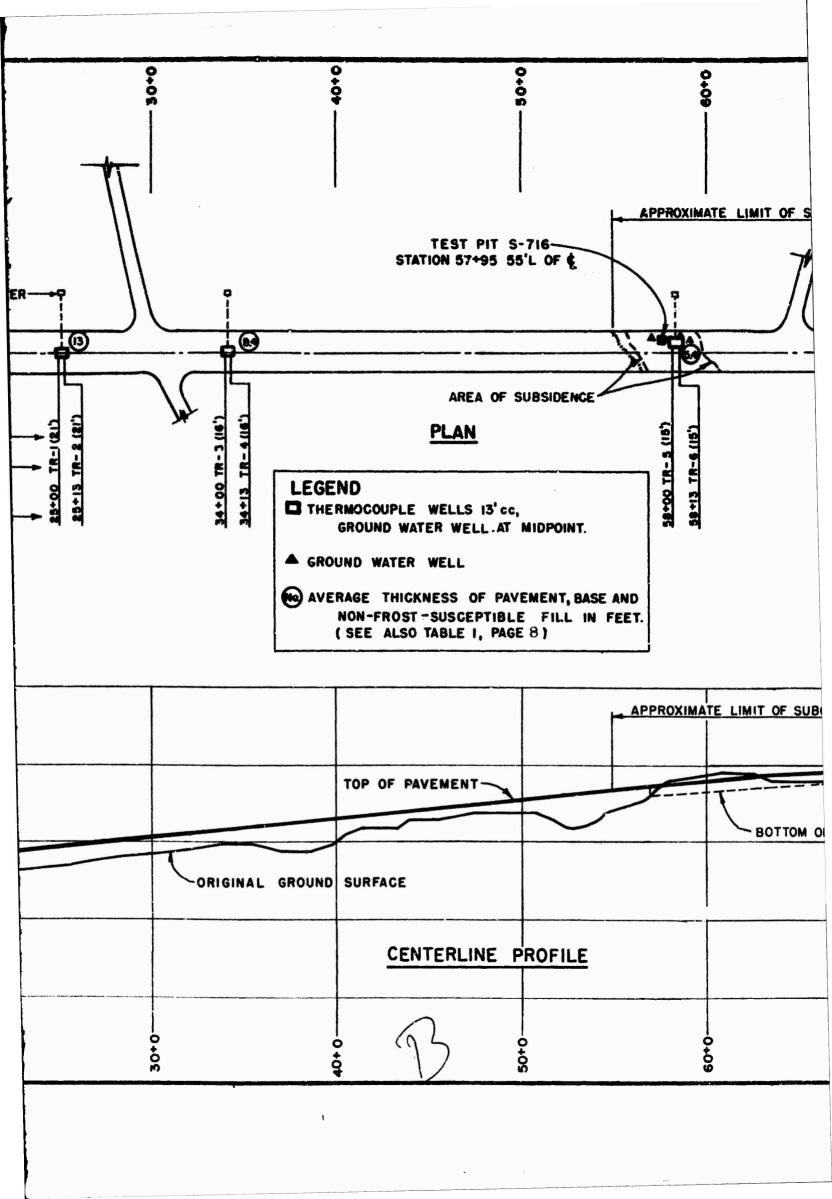
- c. Localized subsidences during a single thawing season of as much as 2-1/2 inches have been reported by field engineers in each of the two subsidence areas.
- d. Explorations in the subsidence areas reveal that at some locations virtually pure ice masses and high ice content soils exist at or near the subgrade surface. Analyses indicate that where such conditions were found, continued subsidence will occur for several thawing seasons and in some instances may continue for more than 20 years.
- e. Maximum estimated rates of future subsidence in the zones near the ends of the subgrade cut will be of the order of 0.2 feet per year, with this rate progressively decreasing until subsidence is complete.
- f. It is estimated that a total ultimate subsidence of as much as 2.0 to 2.5 feet may occur at some locations.
- g. Because of the irregular nature of the occurrence of the ice masses and high ice content soils in the subgrade, future subsidence will result in uneven pavement surface conditions and possibly abrupt changes in grade. Continued resurfacing of pavement in areas of subsidence to keep the pavement properly smooth for operation of aircraft with high landing and take-off speeds should be anticipated for each of the next several thawing seasons. The area of pavement requiring resurfacing will decrease with succeeding thawing periods.

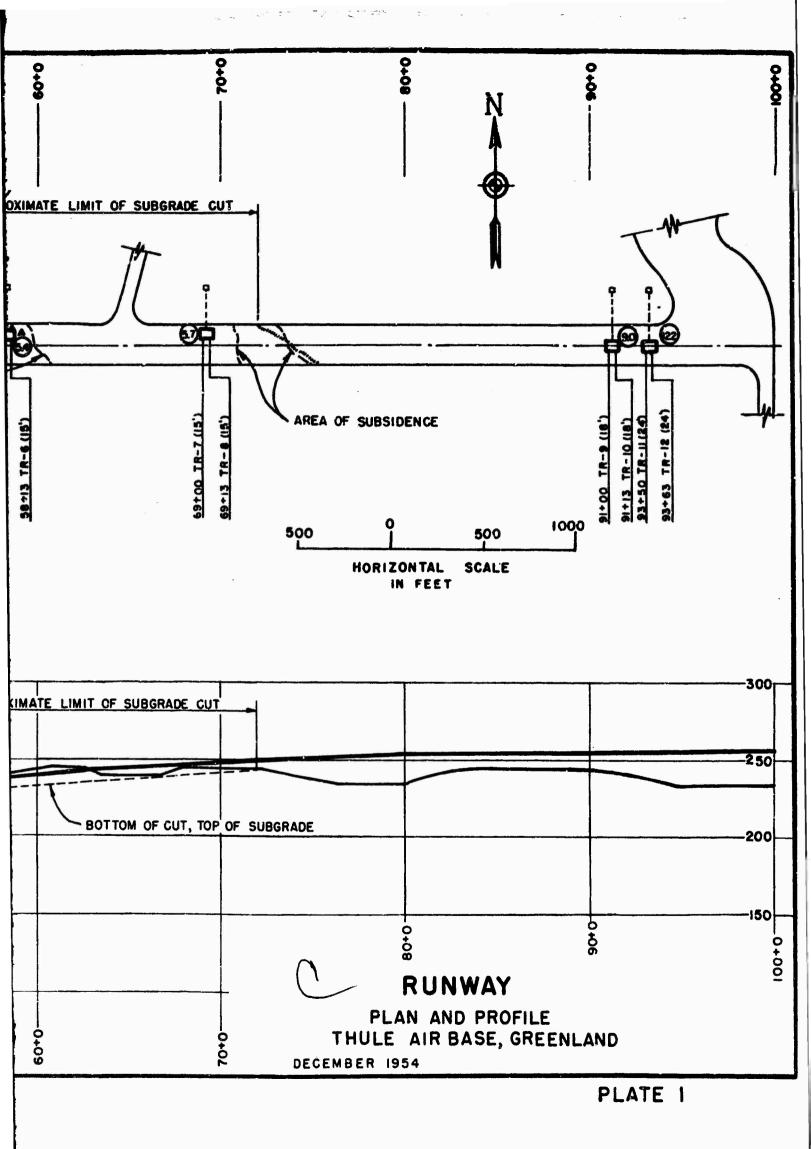
PART V - PECOMENDATIONS

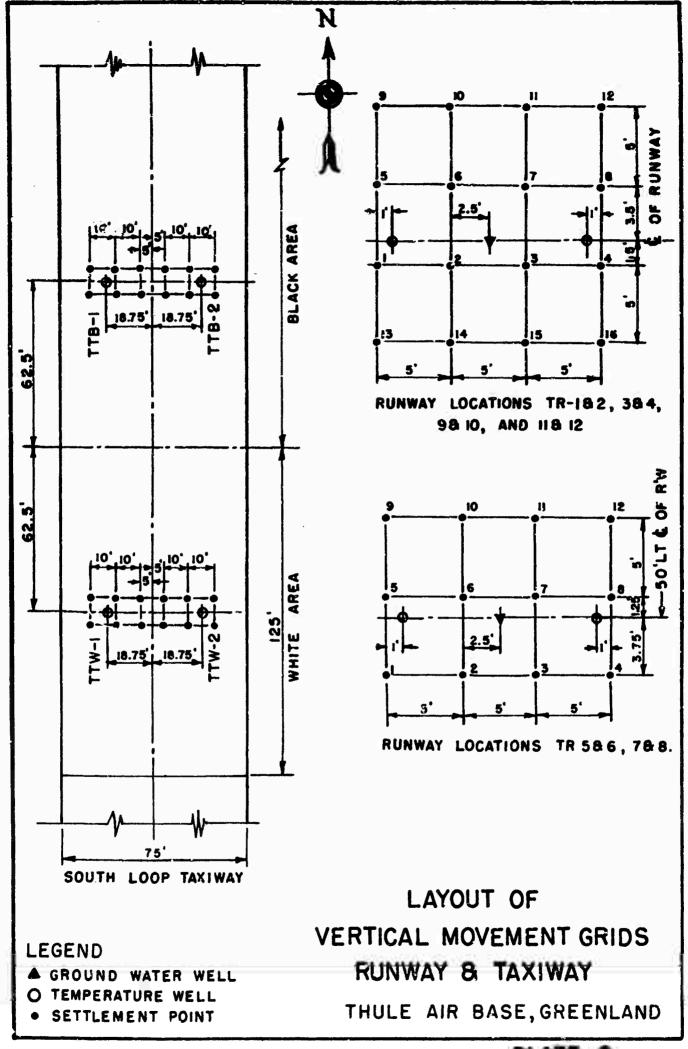
- 5-01. RECOMMENDATIONS. Based on the results of the investigation of the pavement sections at Thule Air Force Base during the 1953 and 1954 thawing seasons, the following recommendations are made:
- a. Maintenance of Existing Pavement. In the subsidence areas it is recommended that one of the two following courses of action be adopted. The selection of course of action will undoubtedly be dictated by runway operational considerations and by the degree to which periodic levelling operations may prove undesirable with time:
- (1) Resurface affected sections of pavement periodically when noticeable or objectionable unevenness develops in the subsidence areas.
- (2) Paint the surface of the pavement white in the subsidence areas so as to reduce depth of that penetration, which for the conditions observed would eliminate further subsidence except for possibly a few isolated small areas.
- b. Future Construction. In additional airfield pavement construction at Thule Air Force Base over subgrade soils containing segregated ice, it is recommended a minimum total thickness of 8 feet of non-frost-susceptible pavement and base, of the type used for past construction at Thule, be provided over the ice-containing materials. Somewhat less than 8 feet of base would be required if non-frost-susceptible material with higher moisture retention characteristics, such as sand, were included in the lower portion of the base course. In fill sections over non-frost-susceptible soils having a naturally ice-free active zone, advantage may be taken of the latter stratum to minimize the height of embankment required.

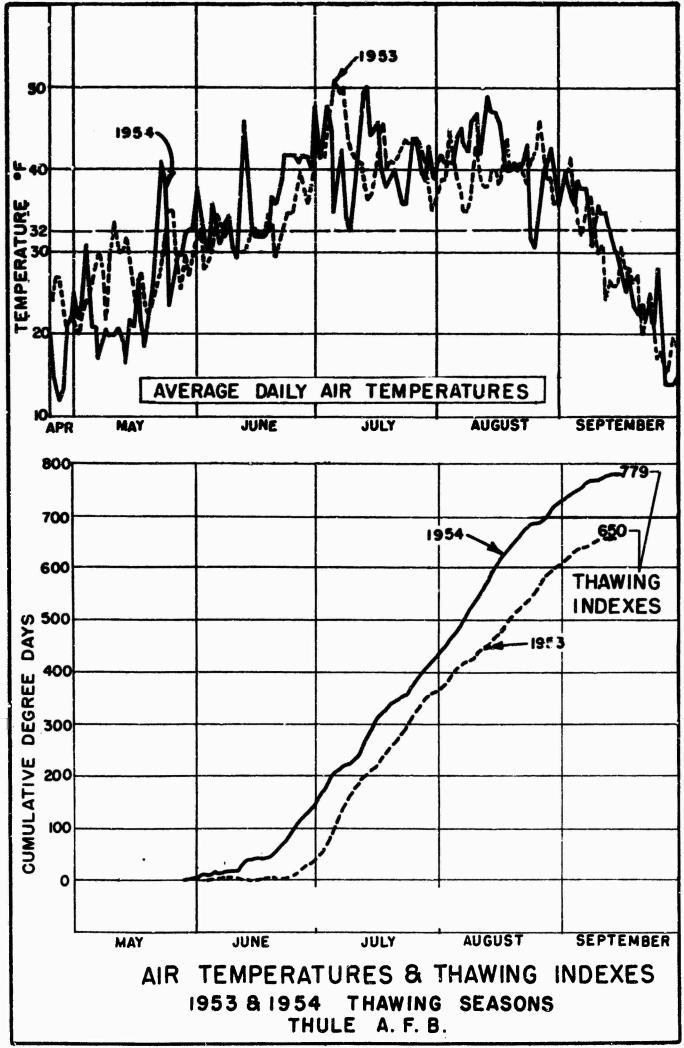
c. Additional Investigations. It is recommended that the field investigations and observations at the runway and taxiway test areas be continued during the 1955 thawing season. It is recommended that personnel of the Arctic Construction and Frest Effects Laboratory visit Thule prior to the start of the thawing period and at time of maximum thaw to determine the surface elevation of the pavement in the subsidence areas. It is recommended that the Eastern Ocean District obtain elevations immediately prior to and immediately following any resurfacing that is done during the thawing period.

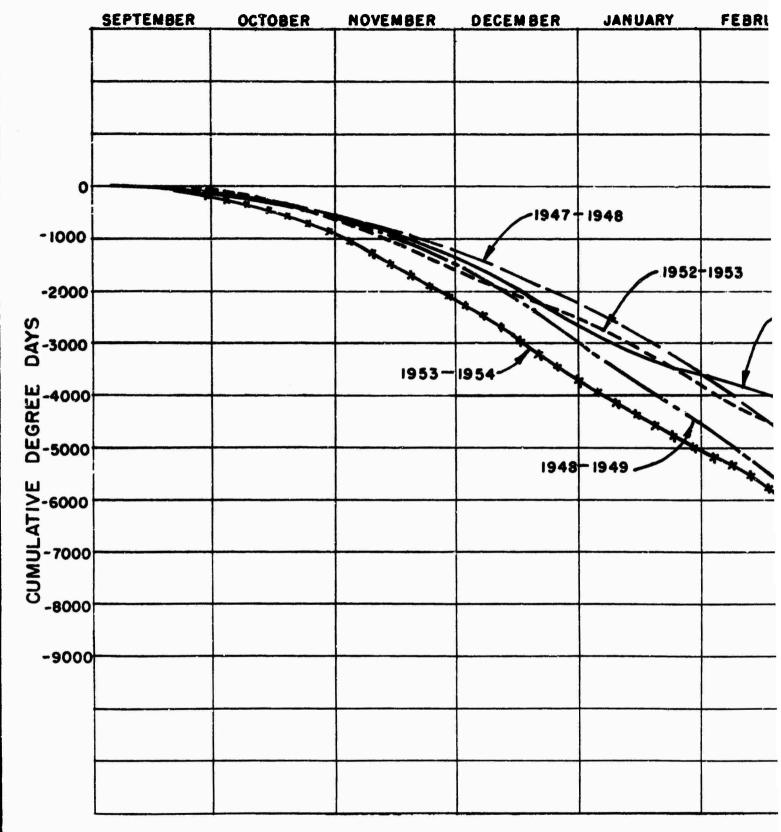












NOTE:

THE 1949-1950 FREEZING SEASON FOLLOWED CLOSELY THE RESULTS OF THE 1948 — 1949 SEASON. THE TOTAL CUMULATIVE DEGREE DAYS WERE 8701.

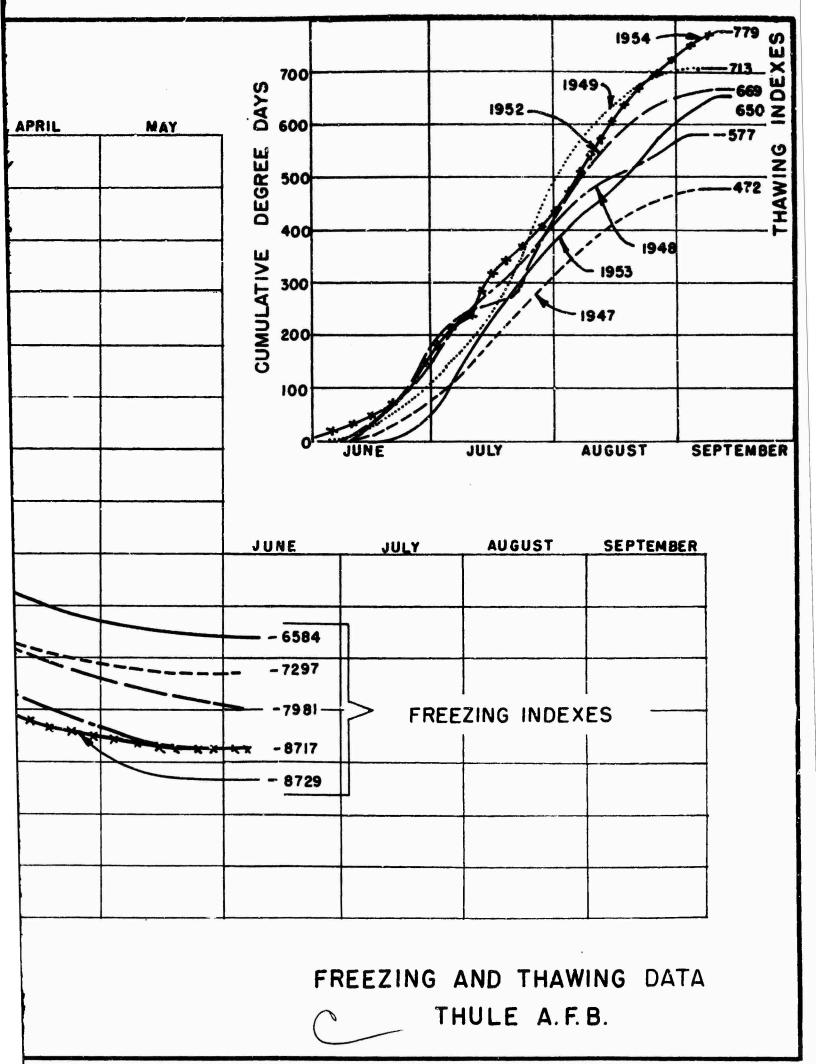


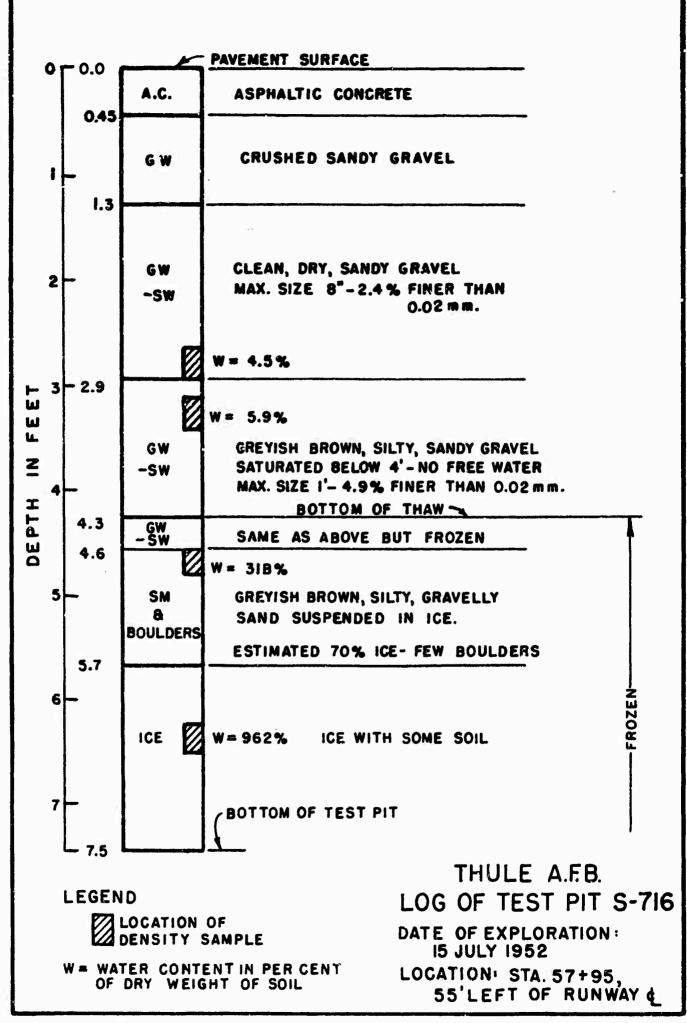
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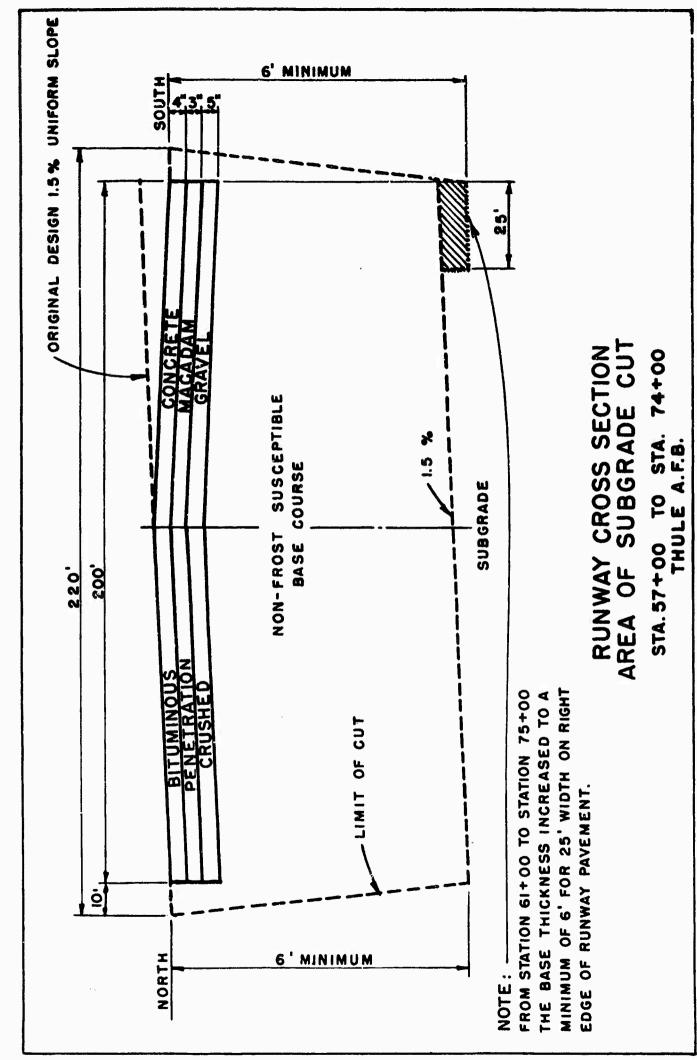
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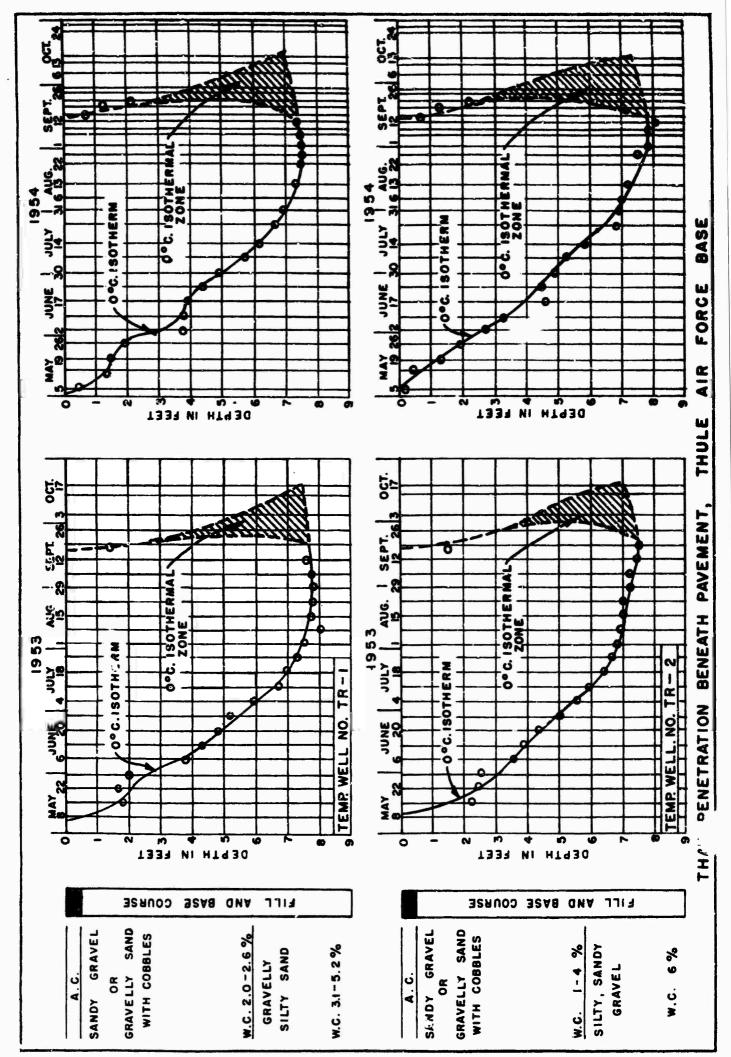
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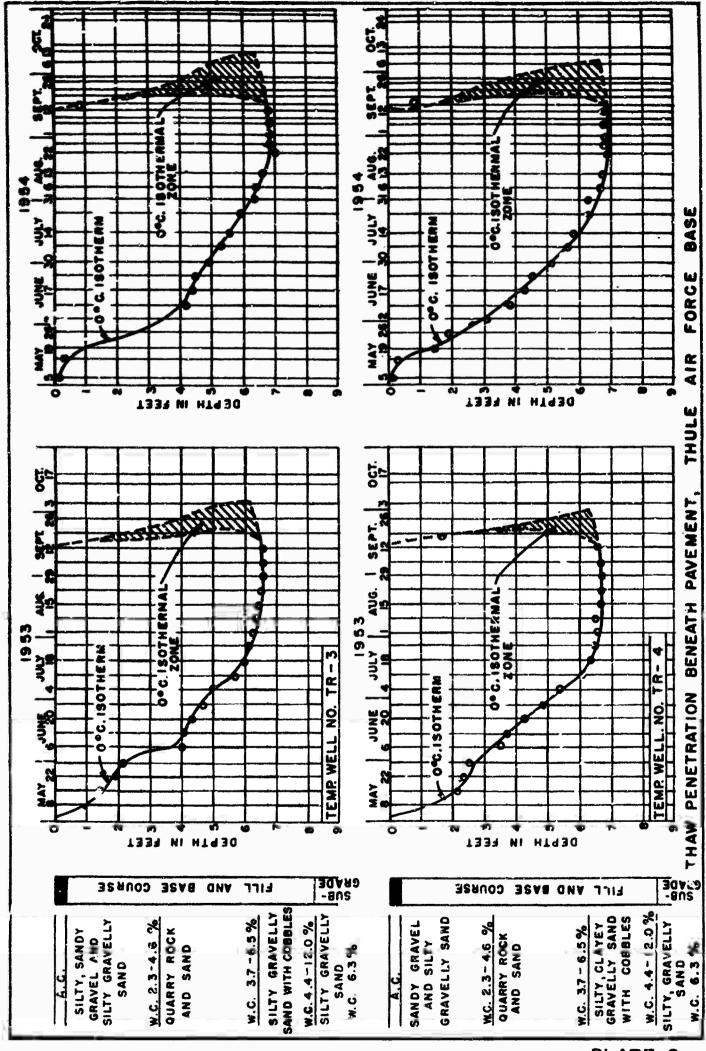


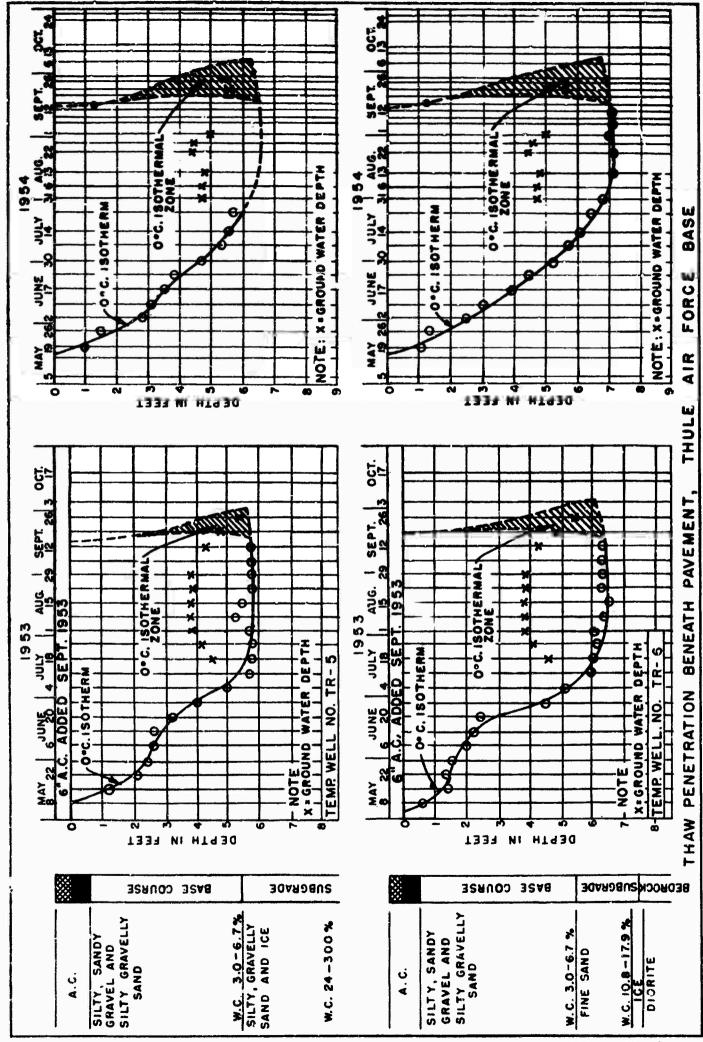












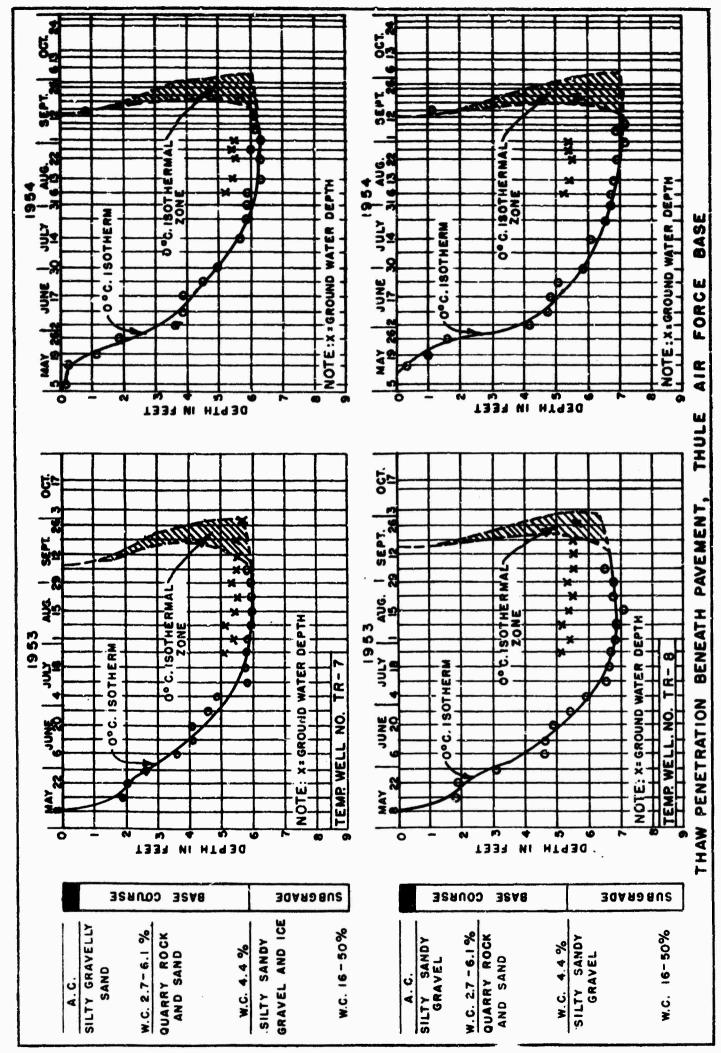
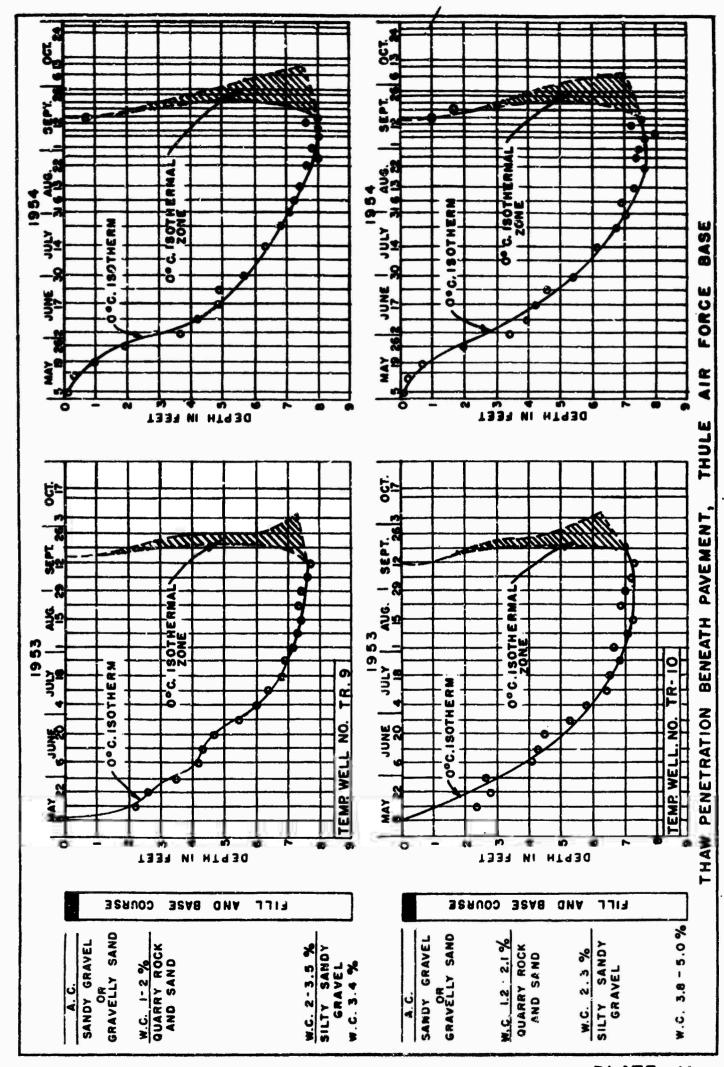
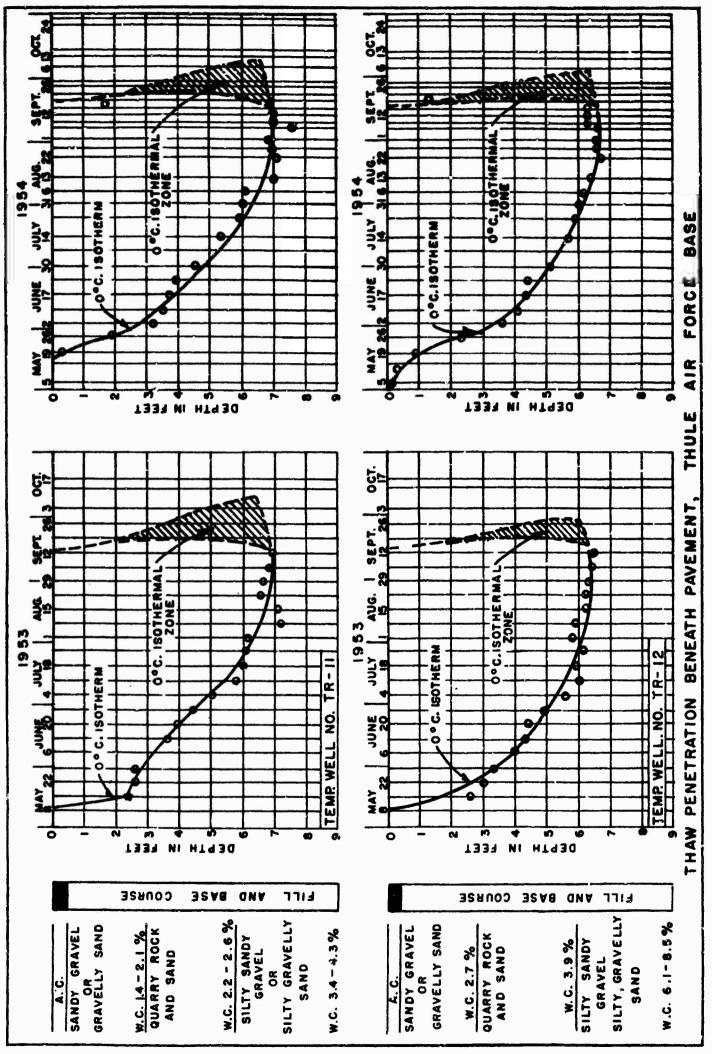
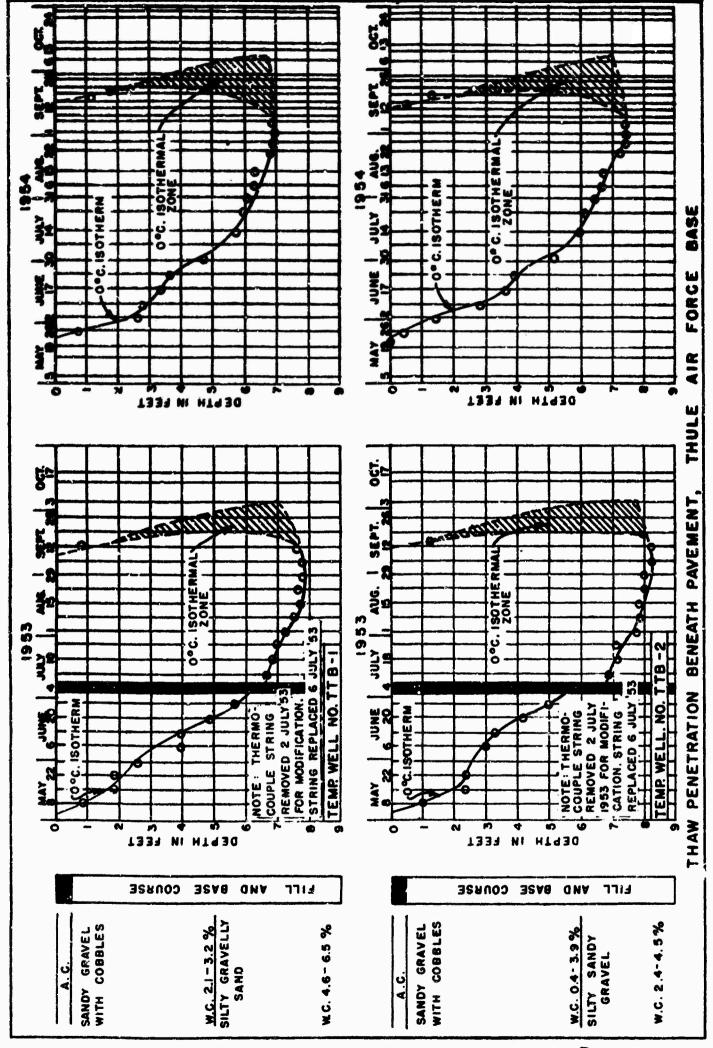


PLATE 10







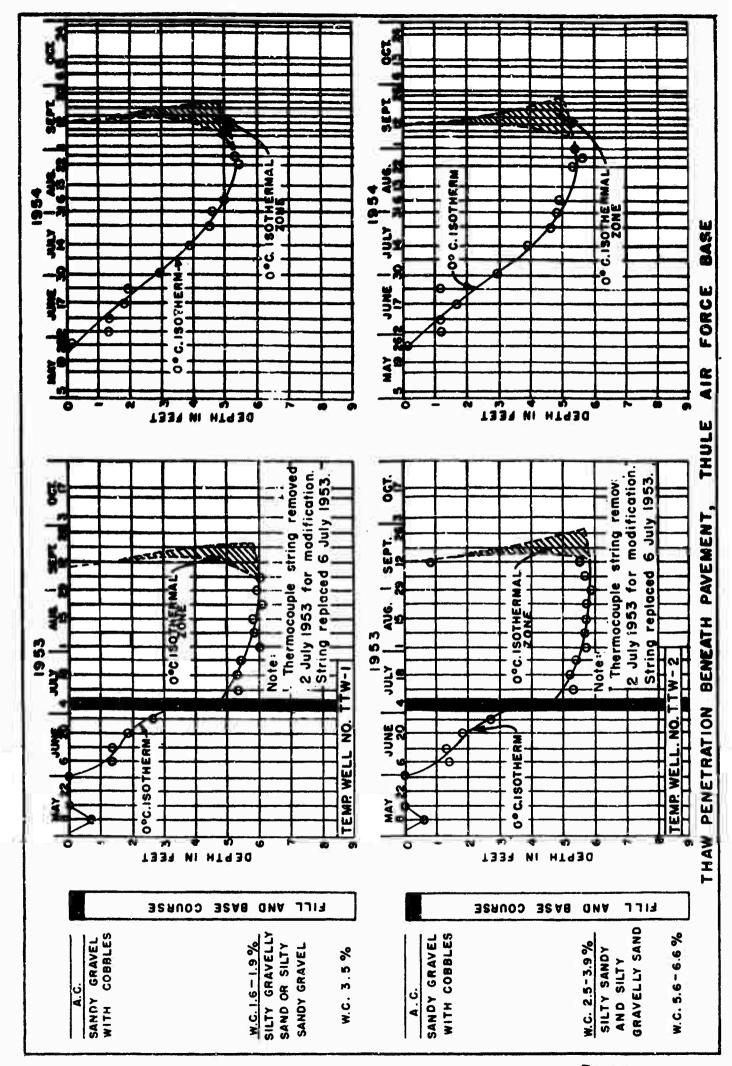
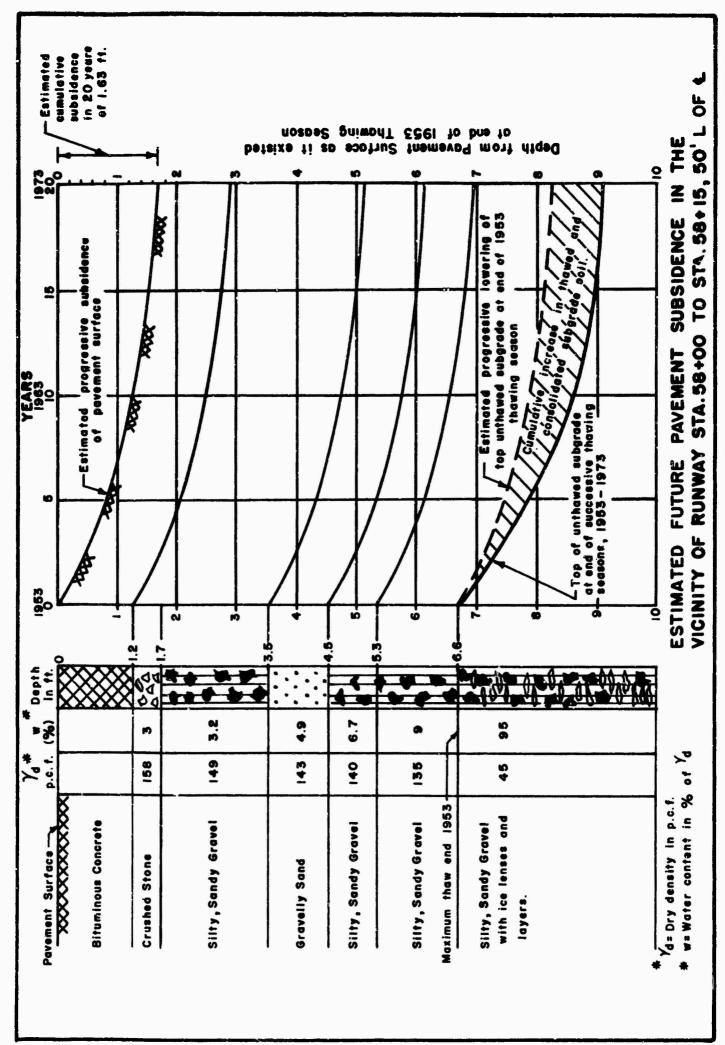


PLATE 14



APPENDIX A

BORING LOGS OF AUNHAY AND TAXIDAY EXPLORATIONS

Prepared

by

METCALF & EDDY

and

ALFRED HOPKINS & ASSOCIATES

Architect-Engineers

Hote No TR #1
Location RUNWAY: STA. 25+00, &
Lob. Sample No. 29-5

1953 F

LOD.	Sample No. 29	-0					12	<u> </u>
۶ ۱						ν		LA
Somote	Graphic Lag	Description & Classification	Density	M C	Comp	Max		-
8			los /cu ft	%	%	Size	12	4
		Bituminous Concrete					!	
0.8'-		Penetration Macadam				i İ		
A 30'	0	Cuttings are light gray, well graded from fine gravel to fine sand-max size = 44". No visible ice Sandy gravel or gravelly sand with coubles		2.0	· · · · · · · · · · · · · · · · · · ·	The No. of the Control of the Contro		
В	OR S	Same as "A" -max. size = Yz".		2.6				
6.0							* ;	:
C		Cuttings are brownish gray mostly fine sand and silt with some organic matter. Some of the organic matter consists of wood chips. No visible ice. Gravelly sitty sand.		<i>5</i> .2				*
D	SM	Same as "C".		3./			de martingua o manuscriba o martinguight	
-11.0'-								
E	S OR SM	Cuttings are brownish gray mostly med to fine sond, with some coarse chips and sixt-may size = 42". No visible ice. Slightly sitty gravely sand with cobbies and a trace of organic matter.		3.0				
-H.O'-	Sentinued							

Metcalf & Eddy and Alfred Hopkins & Associates Project Blue Jay

1953 Permafrost Investigation

					LAI		TORY	 TEST		ATA							
	M C	Comp	Max				PER	 	ER					·····			
1	%	%	Size	17	3	3	Na 4	 		W (00	No 200	02mm	L.	٠.	=	Spet for	
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	2.6		de cari e de cario de companya de cario				•	4									(0)
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	3./				A direct control of the control of t										Andre marks and the continues of the con		4.6
	3.0						Ro		-			•					L.c

igation

Date DH 3-29-53 Submitted by S.B.

ES'	T	DATA							Source	
FII	VER							Sper for	of	Remarks
20	No 40	Vc /00	No 200	C2mm	i	= _	F	30 30 1 ° 9	Material	
									So. River	Cutting from tri-cone retary rock bit Rig bouncing due to coarse gravel and cobbles. Tuttings come up frozen no visible change when thewes in hand
									so. River	Same, slight color change when thawa
									Local Borrew	Cuttings from tri-cone rotary rock bit. Rig bouncing very little Cuttings came up frozen After thawing, color is darker, and is spunyy due to organic matter Chips of light wood appear to be from a plank.
							merit - Anthony Control - Anth		Lecal Borrow	Same, less spongy and no wood chips.
								2	Local Borrow and/or Native Soil	Cuttings from Coring bit. No core recurred Rig bounding bodly at times, then running smoothly due scattered cobbits or buildes Impossible to determine where fill end and native soil begins.

Metcalf & Eddy a

Hale No. TR#1 Location: RUNWAY: .STA. 25+00, & Lab. Sample No. 29-3

1953 Per

	20-10-E-140 C3							<u> </u>	~
2 4	Canadia	Description 9 Classification						LA	BC
200	Graphic Log	Description & Classification	Density das /çu ti	M C	Comp %	Mos Size	14	1	
E	S SM	See sample E" Sheet 1.		3.0		·			
F	SM or GM	Cuttings are grayish brown, mostly fine sand to silt - max, size = 40" No visible ite Snavelly Silty sander sandy silty gravel. Also a trace of Organic matter.		6. >			A THE RESIDENCE AND A THE PROPERTY OF THE PROP		
-#1.5'-	GOR X	Cuttings are brownish gray, well graded from Coarse Sand to Site -Max. Size = 40°. A few chips of ice. Slightly silty sandy gravel with coables and boulders. Also a trace of organic matter.		8.3					
H-22.9-	SW-SM	Brownish grey, well graded, siley gravelly sand. Ice lenses of clear, colorless and herd ice, irregularly Oriented, and massive ice with soil particles in Suspension. Ice = 40% t by volume.		29.7		2"	96	85	8
£									
		^							

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Project Blue Jay

1953 Permafrost Investigation

						LA	BORA	TORY		TEST		DATA	، موسئلات ساخون بود			
	Density	ME	Comp	Mos				PER	ENT	F()	ÈR					
	Ba /çu ff	%	%	Size	14	7	3"	No. 4	No.10	No 20	RG.40	NC -OG	No 200	02 m	Li	.
·		3 .0														
yne Sand Gravelly (ace uf		6.7														
from w Chips ables and		8.9														
y Sand. Tirregularly Ticles in		29.7		2"	96	85	80	78	62	45	32	16	"	6		
					Proposition Associated and the control of the contr											

gation

Date E^{H} 3-23-53 Submitted by 3.B.

51		DATA							Source	
L	iéh		~ 					-5.	01	Remarks
5	Nc. 40	Nc -00	No 200	.02 mm	ند	ē.	.	Specific Scovery	Material	
								·	Local Borraw and/ar Native Soil	See Sample E" Sheet 1.
	-		-				-		1	Cuttings from coring pit. No care recevered Core parrel and bit were control with wet sity send. Rig bouncing slightly.
									Ngtive Soil	Cuttings from coring bit. Only recovery was 2-3"stones. Rig Bouncing badly to 21.0". Hit something hard at 21.0", and rig stopped bouncing, probably on a boulder.
	32	/6	"	6					Native Soil	Core badly broken and partly thewed- 25% recovery. Impossible to run frozen density. Sample may not be representative Hole Completed at 22.9 ft.
										•
									1	

Hale No. 7R *2 Location Rummey Stc. 48+13 - & Leb. Sample No. 30 - S

1953 P

F80' 2	emple No. 30	7-5			-		13	<u> </u>
1 4			r					.LA
10	Graphic Log	Description & Closeification	Deneity	M. C	Comp	Mgx		
3.			Be/cu.ft	%	*	Size	15	\$,
-0.5'-		Bituminovs Concrete Penetrotion Macadam			·			
	6 0 0	Cuttings are musty high brownish gray with some blux chips of squart, mastly sine gravel and charse sand-man. Size the visible ice. Crushed, minus 2%, gravel base course.		14			e u	
В	G OR	Cuttings are brownish gray, mostly med to fine Sand with some coarse chips -mass.size = 15" He visione ice. Sandy gravel or gravely send with cobbses.		4.1,				
C	5	Same as "B", color is gray.		1. 5				
D.	GM	Cuttings are light brownish gray, mostly med. Sand to sit with some coarse chips-max. size=kz*. No visible ice. Silty sandy gravel or silty gravelly Sand with cobbles.		6.1		-		
E	or SM	Same as "D" with a trace of organic matter.		3 .2	Transference and the second se			
-18.6'- F -14.6'-	Sant Guesa	Same as E		2.6				

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Project Blue Jay 1953 Permafrost Investigation

		-						_	11(4)			DATA					
						. LA	DUKA	TORY		TEST	IER	DATA	· · · · · · · · · · · · · · · · · · ·		,		
	Deneity the /cu.ft.	M.C	Comp %	Max. Size	11	*	2	No 4			_	No 400	No.200	.02 mm	LL	P :_	₽:
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***		6.1						manufatte er er e de d									
		3.2					Andrews designation of the contract of the con										
		2.6							B	·							

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Date: DH 3-29-58 Submitted by: S.B.

57		DATA							Source	3.8.
- N	ER							Specific	of	Remarks
	No.40	Mc (00	No.200	.0256	LL	۴_	۶.	Gravity	Material	
									So River	Cuttings from tri-cone rotary mak bis. Penetration macadam mixed with apad, can not tell exact dapth of penetrolism.
The state of the s									So. River	Cuttings from tri-come rotory rock bit. Rig bouncing due to coarse gravel and Cobbies. Cuttings, come up frozen. Sample thewed in bond becomes danger and damp
Ones with a respective service of the service services of the									So. River and/or No. River	Same - Sample thawed in hand has he visible change. Very hard to tell source of material flow cuttings.
The same of the sa					***************************************	en e regentation e e e transie e e e e entre entre e e especiales e especiales e especiales e entre en			Locel Borrow	Same - sample thawed in hand becomes darker and damp
			- Company of the Comp						Local Borraw	Same - no visible change when thewed, but feels slightly spongy.
									Local Borrow Andfor Nătive Soil	Same as above - Impossible to sell from cuttings where bill ends and native soil begins.

Metcalf & Eddy on

Hele No. T.R. #2 Location Flanney: Sta 25415 . E. Leb Semple No. -50--5

1953 Perm

LOD	Sample No	lo-s					19	153 F	<u>ern</u>
2 :		7		# -				LA	BOR
	Graphic Lo	Description & Classification	Density	M.C.	Comp.	Mor	- 10	1 5	5
-	MUNICIA		Bu/cuft	*	*	Size	18	1-	-
F	SM SM	Cuttings are tight brownish gray, mostly med sand to site with some coarse chies and a trate of organic matter. Silly gravely sand or silly sandy gravel with cohbles and organic matter. No visible ice.		2.6					
G	GP-G	Grayish hown, poorly graded, stightly silty sand. with scattered cobbles. A few barely visible ice crystals.		2.8		£"	63	54	15
-172- H -1854	GM X·K	Lice crustels minus Kid and a continue of cleaning	/41.3	7.1		2"	80	74	67
J	GN	Same as "H", but much ice Impossible to describe ice conditions, because sample is completely thoused.	79.8	37.9	And desired to the control of the co	2"	9.3	73	64
22.5	Completed						r dan district (
					er gefentigen gebiete grenneren en enm - moor				*
		\rightarrow							

Metcalf & Eddy and Alfred Hapkins & Associates

Project Blue Jay

1953 Permatrost Investigation

		Discrey, the same				LA	BORA	TORY		TEST	T I	DATA		-		
	Density	M.C	Comp.	Mos					CENT.		NER		-			
	Ba/cuft		%	Size	15	\$ *	<u>3</u> "	Na 4	Ma IO	Mo.20	No.40	No.100	Na.200	.02 mm.	LL	PL
r wood sand o Of organic grayed with		2.6														
sifty sopol- vistole ice		2.8		2"	63	54	.15	14	37	27	20	13	5	5	A	
y smell Heer ice riel. Ice :	/41.3	7./		2*	80	74	67	EI	54	48	42	30	23	12	/3	: : //
to describe ely thowad.	79.8	37.9	A A CONTRACTOR OF THE CONTRACT	2"	93	73	64	57	50	43	30	27*	20	9	16	
													o and the adjustment and the second			
															- A community of the co	
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tigation

Date DH 3-29-53 Submitted by: S. B.

			_							
EST DATA					_	Source				
FIL	ER							Sperific	of	Remarks
20	No.40	No.100	No.200	.02 mm.	LL	PL	PΙ	Gravity	Material	
								* * *	Local Borrow and/or Native Soil.	See Sample"F" sheet 1.
7	20	13	9	5					Local Berrow Andfer Native Soil.	Core badly crumpled - 20% recovery. The sample consisted of loose gravel and l%" piece of undisturbed core. Tests are unraliable because sample may not be representative.
8	12	30	23	12	13	"	.2	2.01	Local Borrow Andjar Native Soil .	Core broken, but good-100% recovery.
5	30 .	27	20	9	16	13	3	en e	Native Soil	Core completely crumbled and thawad- 25% recovery. Sample same out of core barrel in form of mud. Tests on this sample are unreliable. Hole completed at 22.3'.
	**									

PLATE A4

Hale No. TR#3
Location Runway: Sta. 34+00-£
Lob. Sample No. . 31-5

Los. Sample no 37-3												
2 4			Description & Charliffeetion			·			LA	BOR		
3	Graphic Log		Description & Classification	Density But/Cu ft	M C.	Comp.	Mox. Size	1 g	3.	3"		
-0.5'-	7	MÀ	Bituminous Concrete. Penetratian Macadam.									
	0,0	Z Z Z Z	Brannish grey, minus 212°, crushed gravel base course. No visjale ica - poorly bondad. Light brownish grey, vary clean, well graded, gravely	156.9	2.3	100+	2"	87	64	15		
B 2.0		SP IX-NP	3000. Sand grains all rounded. No visible ice-pearly bonded. Derk brownish gray, poorly graded, gravelly sand with 8 trace of organic matter. A few small ica crystals-pools beau	151.0	4.6	100+	2"	95	87	6 /		
C		GP IX	Dark brownish gray, poorly graded, sandy gravel with a trace of organic matter. A few barely visible ice crystals - well bonded.	150.6	3.2	100+	2"	90	86	6.5		
D -3.5	LITA	SP-SM IX-NP SP-SM	Patches of dark brownish gray, sandy gravel and patches of dark brownish gray, peerly graded, silty gravely sand. A few barely visible ice crystals. Gravel is quite friable, sand is well bonded.	<i> 5</i> 2.3	4.3	100+	2"	95	27	. 77		
E -4.5	147	ROCK NP	Dark brownish gray, poorly graded, slightly silty, gravelly diorize sand, and diorite quarry rock. Quarry rock zark to by volume. No visible ice - friable.		3.7	1 1 1	2"	91	76	66		
F -5.3'-			Same as "E" - quarry rock = 50% ± by volume. Ice crystals, up to 19", adhering to rock - friends. Poorly phased, sandy graves.	151.0	6.2	100+	2"	85	61	وي		
G.0'-		SP ROCK	Contact with voids up to 3". Peorly graded, graves, sand. 30% t digrite sand, 30% t digrite guarry rosk, 40% t	147.8	6.5	99.2	۳ ح	88	72	64.		
-;;; -;;;		IX-IC	local barraw. Local barrow is silty sandy gravel. Many ico crystals and some ico lenses in local barraw. Ico 2007st. Greyish brown; Silty, clayey gravelly sand with coubles. Many ICO Crystals and No "thick, irregularly etiented ice lenses. Ico 210% t by volume. Also a Eroce of organic matter.	/24.6	12.0		1/2"	100	84	74		
7.7	-1]\	SP-SM	Some os "H", but less silt and no ice lenses	141.0	6.4	} 	2"	90	78	65		
K -8.5		IX	Same as "J"	143.5	4.4	•	142"	100	80	63		
9.0-		SM IX-IC	Same as W" - coating of ice around gravel, no ice lenses.	138.3	6.3		1/2"	98	88	₿o		
M 10.6		SM	Grayish brown, silty gravelly sand with a few cobbles and a small amount of organic matter. Many ice crystals and a few thin ite lenses. The ice is cloudy to dirty and quite soft. Ice = 5%2 by volume.	135,9	7.6		2"	93	85	75		
N		IX-11	Same as "M" - ice 210% t by volume, no organic matter.	132.2	9.8		2"	96	85	76		
P -11.8'-			Same as "M"-ice > 20% t by volume, no organic matter, color is brownish gray.	117.6	15.7		2"	94	85"	76		
R -13,0		GM or SM	Cuttings are brownish gray, mostly med sand to silt with some coorse chips -mer size = ½". Cutions come up in a shawed state and very wet. About to a film cuttings appear to be diorite. Probably badly fractured diorite and till with ice Impossible to describe use condition.		15.4							
14:0'-	500141	mv.	Same as"R" - more divrite custings		14.7							

Metcalf & Eddy and Alfred Hopkins & Associates

Project Blue Jay

1953 Permafrost Investigation

		:			LA	BORA	TORY		TES1	r 1	DATA						
ensity	MC	Come	Mos.				PER	CENT		VER	······································						Se
Acu H	*	.%	Sure	lģ	1	7_	Na 4	No.10	Na.20	No.40	Na 100	No.200	.02 mm.	LL	PL	Pi	G
5.9	2.3	100+	2"	87		15	35	27	19	/2	ح	3			(1	:	2
1.0	4.6	100 t	2"	95	87	0/	74	6/	43	28	9	1		!		1	2.
0.6	3.2	100+	2"	90	86	59	50	43	33	23		5-				<u>.</u>	2.
								·								1	
2.3	4.3	100+	2"	95	87	77	7/	60	14	30	12	•	4		į		
	3.7	1	2"	: • 91	. 76	66	58	50	30	27	10	ح			i		
		1		:			į			i				!			
7.0	8.2	100+	2"	85	61	50	43	30	29	20	3	5	2		1	1	
		•		:					-		1		i i	t 1	:	4	
7.8	6.5	93.Z	2"	88	72	64.	58	43	36	23	•	4	!	!			:
			. 4 4	!							!						1
1.6	12.0		1/2"	100	84	74	66	59	51	44	30	21	/3	<i>]</i> 19	15	4	
1.0	5.4	1	2"	90	78	65	56	50	41	3/	18	11	6	!	:	1	
3.5	4.4		142"	100	80	63	62	56	45.	34	18	"	7	<u>:</u>		: i	
8.3	6.3		152"	28	88	80	72	66	57	48	33	20	//	15	. 13	2	2. e
			2"		85	ا	0.79			10	35-	27					
5.9	7.6		6	93	85	75	67	61	54	70	53	41	14	16	14	2.	
2.2	8.8		z"	96	85	76	67	61	56	50	37	30	19	17	14	3	
												<u> </u>					
7.6	15.7		2"	94	8.5	76	68	61	54	45 .	29	2/	9	/4	non p	238/G	•
	:	:	•		•												
	15.4	i														,	1
																	:
	14.7								n								{
	7.7								11/2								

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Date: DH 3-29-53: TP 4-7-53 to 4-10-58

Submitted by: S. S.

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-										300 miles 07 · 6. D.				
51	ST DATA								Source					
FINER					Specific	01	Remorks							
źo	No.40	No.100	No.200	.02 mm.	LL	PL	Pi	Gravity	Material	·				
				·						Samples Athru P, 0.7'-113', are all trocks church from test pie.				
	/2	5	3					2.78	So. River	Sample A includes both the base course and Sa River and. Impossible to separate and get a good frozen chunk - too friable.				
5	28	9	1	-			! !	2.79	No. Mountain	Diarite sand with badly decomposed diorite chunks -neak. Size = 4".				
\$	23	•	5-					; ;2.79	No. River and No. Mountain	A mixture of No. River gravel and No. Mountain Sand. No. River material = 75%2.				
	30	12		4		! !		•	No. River ond No. Mountain	The two materials are not mired. No. River gravel = 50 % 2. Seed is No Momental diorite.				
2	27	10	حی					I	No. Mountain and F-Quarry	Mex. size of quarry rock = 10". Too frishe to run frozen density.				
	20	9	حی	2		8 7 1 3 4 8	! :	-	Po. Mountain and F" Quarry	Max. Size of quarry rock = 3'				
	23	•	4		•		·	:	No. Meuntain and F" a varry	Same. No sample taken in this zone. Material				
	44	30	21	/3	19	15	4		Local Borrow	from 3 sources all inter-timpered-yery hard to get a representative sample.				
	3/	18	· //	6			!	į	Local Borrow	Max. size = 1.5"				
	34	18	"	7		:	: :		Local Borrew	Mar. size = 2.0" - No sharp line between local borrow, and native sail. The zone from				
	48	33	20	"	15	, /3	2	2.01	Native Soil	local barrow, and pative sull. The zone from 8.0' to 8.5' is a mixture of barrow and native sul Max. Size = 8"				
	18	35-	27	14	16	14	2.	: : :	Wative Soil	Mer. size = 0 "				
	50	37	30	19	17	14	3		Wive Soil	Max. size = 2,0'				
	45 .	29	2/	9	14	non pl	estic	•	Native Soil	Mex. size = 2.0'				
							,	; ;	Native Soil	Cuttings from tri-cone rotary rack bit. M.C. unreliable - probably low.				
						_			Native Soil	Same				

PLATE A5

Metcalf & Eddy an
Pro
1953 Perr

icie No. TR "3 ocetici: Runway: Sta 34+00 - £ oto. Somple No. 31-3

° 4	Somple 760. 3/		Y					LA	
	Graphic Log	Description & Classification	Density	M C	Comp	Mexx.			
			Ba./cuft	%	۹.	Size	15	1	- 3
T	GM SM	See sample"T"=Sheet 1		14.7			·		
U 17.0'-	ROCK and GM or SM	Cuttings are mostly gray diorite, graded from med sand to silt with a few coarse chips-noak. Size: 45°. Cuttings came up thawad and very wet. Probably badly fractured diorite with much 160 and a single amount of till. No way of descripting ice condition.	•	12.7					
							•	; ;	
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				: : : :	; ;				1
		A					manufacturing spectrum of the visit		

Project Blue Jay

1953 Permafrost Investigation

_		LABORATORY TEST DATA															
						LA	BORA			TEST		DATA					
	Density	M C	Comp	Mos.	·		475	PER	7	_	ER	,				P .	و ا
\hat{T}_{ij}	Ba/cuft	%	%	Size	14	ž	3,,	Na 4	No.10	No.20	No.40	No:00	No.200	.02 mm	LL		
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7		12.7						•				<u> </u>			•		
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Date: DH 3-29-52: TP4-7-53 to 4-10-55

Submitted by 5.8.

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Γ :	DATA	•			***************************************			Source	
NER							. 5 4 -	of	Remarks
	No 100	No.200	.02 mm	LL	ΡĹ	,	Specific Gravity	Material	
·							·	Native Soil	See sample"T"-sheet 2.
						, ÷		Native Sail and/ar Bed Rock	Cuttings from tri-cone notary rock bit. iM.C. unreliable -probably low. This appears to be the upper zone of diorite bed rock. Hole completed at 17.0 ft.
		• • • • • • • • • • • • • • • • • • •							
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	<u>i </u>	<u>.</u>	L		<u>;</u>	!	·		PLATE

Hole No. TR#4 Location Runway: Sta. 34+13 - £ Lab. Sample No. 32 - 5

\$ £						4		LAS
100	Graphic Log	Description & Classification	Density	M C.	Comp	Max		**************************************
3			lbs./cu ft.	%	%	Size	17	3
-0.5		Bituminous Concrete						;
_0.0	NY YYY	Penetration Macadam Brownish grey, minus ale, Crushed gravel base course.					1	
F-2:	F	NO VISIBLE ICE - poorly bonded. Light brownish gray, very clean, well graded, gravelly	156.9	2. T	100+	€"	87	64
-1.4'-	SP	Sand Sand grains all residuate. No visible ice pourly bonded.		!		i	į	
В		Derk brownish grey; reorly greded, grevelly send with a trace of organic matter. A few small ice crystals-poorly bands.	<i>151.0</i>	4.6	100+	2"	95	87
C	GP IX	Dark brownish gray, poorly graded sandy gravel inith a trace of organic master. A few barely visible ice cryspals—well bonded.	150.6	3.2	100+	2"	90	06
D	SP-SM X-NP	Petches of dark brownish grey sandy gravel and petches of dark brownish gray, peorly graded, silty	152.3	4.3	100+	2"	95	87
3.4	SP-SM	gravely sand. A few barely visible ice crystals dravel is quite frience, sand is well bonded. Dark brownish gray, poorly graded, slightly silty,					į	
E	ROCK	gravelly, diorite sand; mixed with diorite quarry fack. Rock = 25% t by volume. No visible ice-triable.		3.7		2"	9/	76
F	GP ROCK	Same as "E" - guarry rack = 50% ± by volume. Ice crystals, up to 16", adhering to rock - poorly bonded.					1	
-5.8'-	W-NP	reerly grades, Eandy gravel.	151.0	6.2	100+	2"	85	6/
G	ROCK	Same 43 E - quarry rock = 75% t by volume. Ice crystels enhance to rock and also in sand. Rock to rock contact with volds up to 3". Gravelly sand.	/47.8	6.5	99,2	z"	. 88	72
2.0-		30% t diorite 44nd, 30% t quarry rack, 40% t local borrow. Lacel borrow is silty sondy grave! Many ict Crystals and some thin ice leases in local borrow. Ice:10% t					•	
H -7.0	S/1-SC IX-IC	Grapish troug, Sity, Claysy grovelly sand with cabbles and a trace of organic moster. Many small ice crystals and a few in ignorably oriented, ice tenses. Ice 2 10% by volume.	124.6	12.0		112"	100	84
7.7	k : 1	Same as N"-less silt and no ice lenses. Ice = less than 5% by volume.	141.0	6.4		2"	90	70
K	X X	Some as"."	149,5	4.4		1/2"	100	80
8.6'-	SM IIIX-IC	Granish brown, silty, gravelly sand with cabbles and a trace of organic matter. Many ice crystals and all gravel casted with ice.	138.3	6.3		1/2"	98	88
М		Grayish brown, silty, gravely sand with cabbles and a small amount of organic matter. Many lice crystals and a few thin, irregularly oriented, ice lenses. Ice is cloudy to dirty and quite 3eft; = 5% to by volume.	135.9	7.6		2"	93	85
Nas	IX-11	Same as'M"-ice=10% t by volume, non-organic.	132.2	8.6		2"	96	85
P		Same as "M"-ice=20% by volume, non-organic.	117.6	15.7		2"	94	85
11.3		Cuttings are light brownish gray, mostly med. sand						
Q 13.0'-	GM or SM	to silt with some coorse chips -mar. sixe = 40". A few chips of ice, but most of the cuttings are thewed and very wes. About 50% of the cuttings appear to be diorite. Probably badly fractured diorite and till with much ice. Impossible to describe ice condition.		17.6				
R -Mo:	-on-lived	Same as "R" - more diorite.		18.0				

Project Blue Jay

1953 Permafrost Investigation

				-	LA	BORA	TORY		TEST		DATA						
ensity	M C.	Comp	Migr		·	,	PER	CENT	Fil	VER	_						Spe
/cu ft.	%	%	Size	15	\$.	3,	Na 4	No IC	No.20	No.40	No.100	No 200	.02 mm.	الد	-		500
					•					• •							
5 9	2. \$	100+	2"	87	64	45	35	27	/>	12	5	3	<u> </u>		;		2.7
.0	4.6	100+	2"	25	87	8/	74	61	13	20	9	4		: :			2.7
0.6	3.2	100+	2"	, 90	. 86	59	50	43	33	23		5	<u>.</u>	:	ş		2.75
			İ		ŧ				!	•		•		:	1	•	
E.S	4.3	100+	2"	95	87	77	7/	60	14	30	/2	: 8	; + !			. In	
	3.7		2"	91	76	66	58	50	38	27	10	5	i		:		
				1	•	į		} [!			; ;			<u>:</u>	
1.0	6.2	100+	2"	85	6/	50	43	30	29	20	, 5	5	2		:		
7.8	6.5	99,2	z"	, 88	72	64	58	49	36	23	, ,	4	•		•		
				•		<i>!</i>	!		!	•		1					
1.6	12.0	İ	11/2"	100	84	74	66	59	51	44	30	: 21	: /3	19	15	· :	
					!	1	i	ł	1		į.	; :		,			
	6.4	İ	2"	90	70	65	56	50	: 41	3/	/8	"	6	:	•		
3.5	4.4		11/2"	100	80	69	62	56	45	34	18	. "	7				
3.3	6.5	•	1/2"	98	80	80	72	66	57	48	33	20	"	. 15	/3	2	2.8
7.9	7.6	:	2"	93	85	75	67	61	54	48	35	27	14	. 16	. 14	2	
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:. 2	8.8	İ	2"	96	85	76	67	61	56	50	37	30	/9	17	14	3	
6	15.7	! !	2"	94	85	76	•	6/	54	45		2	9	14	1	Nostic	
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Date DH 3-29-53: TP 4-7-53 64-10-53

Submitted by S.B.

EST		DATA							Source	
FIN	ER							Specific	of	Remarks
20	No.40	No.100	No 200	.02mm.	<u>.</u>	F -	. . .	Grav ty	Material	
						•				· Samples Athru P, 0.8'-11.3', Ore all frozen chunks from test pit.
	12 .	5	3			:		2.78	So. River	Sample'A includes both the base course and So. River Sand. Impossible to separate and get a good fragen chunk-to frieble.
3	20	9	4		•			2.79		Diorite sand with body decomposed diorite Chunks-max. size : 4".
•	23	9	5	: 	:	:		2.79	No. River and No. Mountain	A mixture of No. River gravel and No. Mountain diorite Sand. No River gravel = 757a±.
•	30	/2	8	+		:	•		Seme	Same, but the two materials not inter-
8	27	:0	5	:		: : :			No. Mountain and F" Quarry	Max. size of quarry rock = 10". Too frieble to run frezen density.
•	20	وا	-	2	•	:			Same	Max. size of quarry rock = 3'.
	28 9 4								Same	Same.
	•	•	1 ! :				•			No sample taken in this zone Material from 3 sources, all intertingered - very hard to get a representative sample.
	14	30	. 21	/3	19	15	4		Local Borrow	Max. Size Cobble = 8"
	3/	' /8	. //	6	;	•		}	Local Borrow	Mox. Size 218'.
;	34	18	"	7					Local Borrow	Max. size : 2.0. No sharp break between local borrow and native soil. The zone from
7	40	: · 33	20	//	15	/3	2	2.61	Native Soil	8.0' to 8.5' is a mature of borrow and native Seil. Max. Size = 8"
	4.8	35	27	14	16	14	2		Native Soil	Max. size = 2.0'
	so	37	30	/9	17	14	3		Native Soil	Max. siza =20°
	45	29	2/	9	14	non-	plastic		stative Soil	Mex. size = 2.0'
						:			Metive Soil	Cuttings from tri-cone intery rock bit. M.C. unreliable - probably low.
								0	Native Soil	Sim a

Metcalf & Eddy o

Hote No. TR #4 Location Runway: Ste. 84913 - É Lob. Sample No. 32 - S

L	.00. 5	ample No. 32	-3					17	55 .	드
ſ	No.			-					LA	B
	20 00 e	Graphic Log	Description & Classification	Density Sta. /cu ft	M. C	Comp.	.Mox. Size	1 🛊	3.	
	R	GM SM	See sample "A" sheet 1		18.0					
	T	14:14:15	Cuttings are mostly gray diorise, graded from med. sand to site with a few coance chips - man, size = 46. A few chips of ice, but most of the cuttings are thewed and vary wes. Badly fractured diorite with a small amount of till and much ice. Impossible to describe ice condition.		15.5					
		Completed								
							:	• •		:
						1		•		
						2 m m m m m m m m m m m m m m m m m m m		:		
						: 1 :				
	I									
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			X	٠						

Project Blue Jay 1953 Permafrost Investigation

LABORATORY TEST DATA																	
.	Dens-tr	M. C.	Comp.	Mas.				PER	ENT		ER					20	
	be Au ft	%	%	Size	14	3,	1,"	Na 4	No. 10	CS.AM	No.40	No IOO	No.200	.02 mm.	LL	PE	P
		18.0											·				
														-		† 1	
																:	
'		15.5														•	
İ															: !	!	:
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Date DH 3-29-53:TP4-7-53 to 4-10-53 Submitted by . S.B.

			-							Submitted by . 3.8,
ES ¹		DATA							Source	
FI	VER							Sacriti	of	Remorks
20	No.40	No 100	No.200	.02 mm.	LL	PĿ	P :	Specific Gravity	Material	
				·					Native Sail	See sample "R" sheet /
				:				:	Netive Sail And for Bad Rock	Cuttings from tri-cone resery rock bit. M.C. unreliable -probably law. This appears to be the upper zone of dionite bed rock. Hole completed at 17.0 ft.
					!					
					i :	:				
	7 8 0 180 0 0 1 100 0 0 0 0 0 0 0 0 0 0 0					•				
					:	and the state of t				
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					The state of the s					
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Metcalf & Eddy or

Hole No. TR #5
1.ocotion Runway; ste. se+o-so'Lt. &
Lab. Sample No. 33-5

1953 Peri

	ample No. 3	J-0						700	
e to	Canabla I a a	Description & Classification			_		·	LA	80
Semos	Graphic Log	Description & Classification	Densit; lbs./cu.ft.	M C.	Comp %	Max Size	14	1	
		Bituminous Concrete						W	
0.0 1.2:- A	GP NP	Penetration Macadam Light brownish gray, crushed, minus 2½", paorly graded, Sandy gravel. No visible ica - triable	157.9	3.0	100 t	2"	76	47	3.
B.	CP-GM	Grayish brawn, peerly graded, slightly silty, sandy gravel. Some of the gravel coated with a thin film of her	144.8	4.2	99.3	2"	86	64	5.
ر ا	10	Same as "A" with many cobbles.	/49.3	3.2	100+	2"	87	63	5
).5'- D	SP IX-IC	Grayish brown, poorly graded, gravelly sand with many cobbles and builders. Stattered Small ice crystals, the", and grated coated with ice.	143.4	4.9	100+	2"	98	85	. 70
E .,,	GP-GM	Grayish brown, poorly graded, slightly silty, sandy gravel with cobbles. Many small its crystals, and a few thin ice lenses. All gravel coated with ice.	139,9	6.7	92.8	2"	92	79	· ' 6
	GM or SM	Cuttings are grayish brown, mostly fine sand to site, max. size = 12. Hany chips of clear ice. Silty sandy grown or silty gravelly sand. Ice = +20% by volume.		24.3	•		•		•
ر روز –	SM	Grayish brown, silty, gravelly, sand. Ice lenses up to I thick, irregularly oriented thru entire core. Ice is clear, coloriess, and hard = 50% to by volume.	47.5	86.9	• •	2"	90	73	6
4	ICE SM	85% tice by volume. Ice is clear, colorless, and hard. Soil particles Suspended in ice, and a few small pockets of soil. Grayish brown, siley sand.		303.5		#4 sieva	100	100	. 10
ر ا ار	GP-GM	Brownish gray, poorly graded, sity sandy gravel. Ice has no definite shape or orientation. Appears to be a missure of soil and ice. Ice is clear, colorless, and hard, = 60% to by volume. No gravel between 8.5° and 3.0°.	50.6	81.6	•	24	57	57	رسی ا
K	ROCH	Gray, badly fractured, diorite rock. Surfaces along the fracture planes are weathered and color is grayish brown. Fracture planes were wet, but no visible ice.		1.6					Andrew Communication of the control
\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	Olorite	Cuttings are gray diorite, mostly med to fine sand-max. Size = #4 sleve. Diorite bed rock		1.1					

Project Blue Jay

1953 Permafrost Investigation

					LA	BORA	TORY		TES1		DATA					
Densit,	M C.	Comp	Mgz				PERC	ENT	FIR	IER						
iba./cu ft.	%	%	Size	14	\$.	3'	No 4	No 10	No.20	No.40	No 100	No 200	.02 mm.	· LL	2 -	Ρ
												-				
157.9	3 .c	/00†	2"	76	47	34	26	19	/3	9	ح	3		 	!	
/44.8	4.2	39. z	2"	86	64	52	44	38	32	24	12	E	J. 4		;	
/49.3	3.2	100+	2.	87	69	57	47	40	33	25	13	7	·2.1	.	<u>;</u>	
148.4	4.9	100+	2"	28	85	. <i>70</i>	58	17	34	22	9	4			£ :	:
139,9	6.7	92.8	2.	92	. 7 9	62	. 51	42	31	20	12	6	3.3	•	i	-
	24.3	• •		•		•			,				•	i	•	-
47.5	86.9	• • •	2"	90	75	62	57	51	44	36	21	14	8			
	303.5		#4 sieve	100	100	. 100	100	94	84	75	60	45	20	: •	. non-p	jestic
50.6	81.6		24	57	57	51	46	41	36	25	18	12	7	14	non-	owst.
	1.6															
	1	•														
	1.1															
					1		3									
	157.9 144.8 149.5 143.4 133.9	157.9 3.6 144.8 4.2 149.3 3.2 143.4 4.9 139.9 6.7 24.3 47.5 86.9 303.5 50.6 81.6	157.9 3.6 /00+ 141.8 4.2 39.8 149.5 3.2 100+ 143.4 4.9 100+ 139.9 6.7 92.8 24.3 47.5 86.9 303.5 50.6 81.6	157.9 3.0 100+ 2" 141.8 4.2 39.3 2" 143.4 4.9 100+ 2" 133.9 6.7 92.8 2" 147.5 86.9 2" 303.5 304.6 2" 50.6 81.6 2"	157.9 3.0 100+ 2" 76 141.8 4.2 39.3 2" 86 149.5 3.2 100+ 2" 98 139.9 6.7 92.8 2" 92 24.3 2" 90 303.5 2" 4 sieve 100 50.6 81.6 2" 57	157.9	Bankuft N. N. Size II	Barkuft % % % Size II	Barkuft % % % Size 11	Barcott % % % Size 1	Banko II	Backuft % % % Size 1	Barkuft % % % Size 1	Bankuft	Bankuft % % % % Size II	Banku R

Date: DH 3-29-55:TP 4-12-58 to 4-14-68 Submitted by: 4.8.

DATA 6 No 100 No 200 02 mm			-					Source	
6	No 100	No 200	02 mm	·LL	9_	Ρ.	Spec fic	of Material	Rémarks
			•						
	5	3			• • •			So. River	Frazen Chupk from test pis.
	/ 2	6	3.4				: 2.60 ,	'H' Ternece	Some, may. Size : 4°
	/3	7	2.1		!			"H" Terreca	Same - Cobbles, mex. Size = 18"
	9	4	÷		! :	:		"H" Terroca	Same - max. size = 2".
	12	6	3.3	• • •	• · · · · · · · · · · · · · · · · · · ·	•	2.73°	H"Terrace	Same - mer. size = 6"
	2		•	i	•		• · · · · · · · · · · · · · · · · · · ·	"H" Terrace mired with	Cuttings from eri-cone recery rock bit. Rig bouncing stightly - drilling fist.
	2/	14	8					Netive Soil	Care good - 75% recovery
	60	45	20		non-p	/astic	:	Native soil	Core broken - 50 % recovery
	18	12	7	14	non-	olistic	t •	Native Sail.	Care broken - 40 % recovery. Stony to 8.5°, soft to 3.0°, hit rock at 3.0°.
								Bed Rock	Core broken and thawed-75% recovery. Core is 2' long and broke into about 10 pieces when removed from core barrel.
								Bed Rock	Cuttings from tri-cone rotary reck bit. Drilled very herd-rig ren very smoothly
							C		Hole Completed at 16.5'

The second section of the second seco

PLATE A9

Metcaif & Eddy

Hale No. TR **6
Location Runway: Sta. 88+13-50'LE &
Lab. Sample No. 34-5

1953 F

Leb.	Semple No. 34	3- 5					13	33 r
2 5								LA
1 8	Graphic Log	Description & Classification	Density	M C	Conse.	Max		
3 -			Be /cu ft	%	%	Size	14	*.
		Bituminous Concrete) :	
-07-		Penetration Hacadam		-				!
A	NB	Light brownish gray, crusted, minus. 216°, poorly grown, sandy gravel. No visible ice - triable.	157.9	3.0	100+	۶.	76	47
В	GP-GM	Grayish brown, poorly graded, slightly silty, sandy graval. Some of the graval costed with a thin film of ICE.	144.0	4.2	99.3	2"	86	! 64 ,
C -5.5'-	l IC	Same as Be with many couldes.	149.3	3.2	100 f	2-	87	6.9
D	SP IX-IC	Grayish brown, poorly graded, gravelly sand with many cobbies and boulders. Scattered small ice crystals%, and gravel coated with ice.	143.4	4.9	100+	2"	?# i	85 :
E	GP-GM IX-IC	Groyish brown, poorly graded, slightly silty, sandy gravel with cobbles. Many small ice crystals and a few thin ice lenses. All gravel coated with ice.	139,9	6.7	92.8	2-	! ' 92	7 9
E.		Cuttings brownish gray, mastly med sand to silt - mar size = 14". Many chips of pure ica. Silty sandy gravel or silty gravelly sand. Ica = +15%.		10.0	i i		: :	1
G	0 G	Cuttings are gray divite, mostly fine sand-may.tize 240 Sieve. Many Chips of clear ice. Ice 2 + 20%, by volume. Bodly fractured divite rock with ice in all the fractures.		17.3			: 	
7.6'-	ICE ICE	No sample recovered. Ice with possibly same sail suspended in the ice.				!	:	
H		Solid diarite rock					· !	
J		Cuttings are gray diorite, mostly med to fine sand-mak. Size = "To sieve. Diorite rock with a few fracture planes.		4.0				:
100-	ROCK (OIORITE)							
12.0'-		Same as 'J" - Solid bed rock - no ice.		<i>1.2</i>				
L -16.5'-	Completed	Same as 'K"		0.7				

Project Blue Jay

1953 Permafrost Investigation

								1300		34 A			-		
					.	LA	BORA	TORY	-	TEST		DATA			
	Denaity	M C.	Come.	Max				PER	ENT	FII	VER				
	be /cu ff	%	%	Size	14	3	I	Ng 4	No. 10	No.20	No.40	Na.IOC	No.200	02 mm.	LL
							:								
					!	ļ		İ		1					
pearly grade,	157.9	J .0	100+	2.	76	47	34	26	19	13	3	سی ا	3		
				2"	ļ	i			1				!		
ity, sondy	144.8	4.2	99.3		96	54	52	44	38	32	24	12	6	J.4	
	40.4			2"	67					}			_		
	149.3	3,2	100+		87	6.9	57	17	40	35	25	13	7	2:1	-
sand with		 						i 					! .		
u ice crystals,	143.4	4.9	100+	2"	? <i>E</i>	#5 :	70	5A	47	34	22	9	4		
مراسوفون		: !				•	i				i 	; !			
y, sandy stals and a th ice.	133.9	6.7	92.8	2"	' 9z	79	62	51	12	3/	20	12	•	<i>3</i> .3	
d to sitt- andy gravel ar		10.8	; •		:						į	•		;	
		1	:	: 1	•	•				1	<u> </u>	1	1	;	• •
nd - mer. size by volume. frectorss.		17.2	į		1			1 . •		: :			i		• •
ly some soil		1	.1		!		;	; ;				!	•	1 6 1	
		:	!		•	į		;			:	*			i •
		:		İ	!	i i		:		:	!			! !	
d. to fine with a few		4.0	:	Ì	İ			•							:
With & Pen		7.0	!					i i		!	•		į		
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		į	<u>:</u>										! !		
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		i			İ	i									1
		0.7	:										•		
							12								1
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Date: DH 3-29-53: TP4-12-55th 4-14-53

3 0	tion									Date: DH 3-29-53:TP4-12-53&4-44- Submitted by: &6.
51	ER	DATA				1	7		Source	Remorks
6		No.10C	No.200	02 mm	LL	P.	! Pi	Spec fic Growify	Material	
								!		
	9	حی	•			1	!	•	So. River	Frozen chunk trem test pit.
	24	12	6	3.4		* * * * * * * * * * * * * * * * * * *	•	. 2.60	"H" Terrace	Same, mer. size: 4"
	25	/3	7	2:/		• • •		:	H"Terroco	Same - cobbles, max size =12".
	22	9	4		V s . c			1 2 1	N" Terrace	Some - Max, size = 2'.
	20	12	•	<i>3</i> .3	•		:	2.73	H" Terroce	Same-max. size =6"
			•	\$: :	· :		:		"H" Terrace mised with Mative Sail	Cuttings from tri-cone rotory rock bit. Ice chips partly motted, M.E. Unreliable. Rig bouncing due to coarse gravel and, or cabbles.
		•	:	:	•	:	i	: : :	Netive Soil	Cuttings from coring his. No core recovered Rig bouncing badly - drilled hard.
	:		•	:	i i i	; ;		! ~	Native Soil	Cored from 7.2' to 8.2' Very soft from 7.2' to 7.5', very hard from 7.5' to 8.2'. Core recovered is solid district 10' long. Bed mack starts 8t 8.2'. Material overlying bed rock
		: : :		:		•	:	•	Bed Rock	is bestly ice, +75%, which was melted while coring thru diarite.
	!	<u>.</u>	•			! !		•	Bed Rock	Cuttings from tri-cope rotary rock bit. Drills very hard. Rig bounzing slightly due to fractures in the rock.
							1	: !		
						i			Bed Rock	Same - Rig running very smoothly
							a. a. district differen a a septe			·
			i i				e day	. A	Bed Rock	Same as above
				<u> </u>		L		1		Hole completet at 16.5'.

PLATE AIO

Hale No. TR #7
Lecellon Runway: Sta. 69100, 50'LI. &
Lob. Sample No. 36 - 5

1										LA	
	3 2	L	NC LOG	Description & Classification							-
1	10	-		Section & Costinue	Density	M. C.	Conve	Mes.	4.1"	30	Т
	3 ~				he fourt.	%	%	Size	14	•	Ц
I	-0.3'-			Bituminous Cancrete Penetrction Necedom			<u> </u>			·	
1	-0.6'-	7.50	GP	Light brownish gray, minus 212", crushed gravel base							
1	-1.2'-		NP	course. No visible ice, a trace of frest-poorly benied.	155.7	2.7	100+	2"	87	68	
	В,	A	SP-SM IC-IX	Grayish brown, slightly silty, poorly graded gravelly said with a trace of organic matter. A few barely visible ice crystals and some of the gravel coated with ice.	/385	· 6. /	96.3	2"	96	80	
	C		SP IC	Gray, poorly graded, gravelly sond. Some of the gravel coated with a thin film of ice Also a few coates.	M2.3	3.8	100+	5"	87	76	
I	, 2.5	0.0						!			
	D	80	ROCK	Diorite quarry rock chaked with brownish gray diorite sand. Quarry rock = 80% t by volume. Voids up to 6" are common que to bridging of large boulders. No visible ice - frieble.		4.4		2"	87	63	
	•	0.0	NP								
	E		GP-GM	Greyish brown, poorly graded, sitty sandy gravel. Many irregularly oriented ice lenses and masses talk i Icezaonzby w.	117.2	16.0	-	2"	78	63	
	F		GM II	Grayish brown, Silty, Landy gravel with cobbles. Many pregularly orienced ice lenses up to 12" and massive ice around the cobbles. Ice is hard, clear, and cawless, = 30% 2 by volume.	74.9	42.8		2"	9/	76	
	G -0.0**		SM II	Grayish brown, silty gravely sand with scattered cobbles. Many irregularly oriented ice lenses up to K," thick and some massive ice, mostly around the grovel. Ice is clear, colorless and herd, = 40 to by volume.	68.0	50.E		2"	35	8/	
	H			Same as 6", with gray mettling. Ice = 30% t by volume.	85.4	35.2	<u> </u> 	2*	97	93	
	- ال - ال		GM	Brown Silty Sandy gravel with scattered cobbles. Many thin ice leases up to 10". Leases are parallel and 14" i apart, gives soil laminated appearance. Also some massive ice, mostly around stones. Ice = 30% t by volume	84.6	34,9		2"	7.7	69	
	K		15-11	Same as 'J"- occasional larger lenses to 12".	· 88.5	31.4		2"	78	70	
	L 12.0'-		SM-SC	Grayish brown, silty, Clayey, gravelly sandwith scattered cobbles. Many very thin ice lenses up to he thick. Lenses are paralle! and 's' to M' apart, gives soil laminated appearance. Also some massive ice, mostly around stones Ice is clear, colorless, and hard, = 50% t by volume.	45.7	31.8	T	142"	100	86	1
	M.		15-11	Same as "L".	52.0	76.1		11/2"	100	87	
	N -4.0=	ICE	ICE GP-GM	Ice = 90% t by volume. Ice is stratified, layers of clear colorless ice with alternating layers of dirty ice containing suspended particles of gravel, said, and sile.	18.7	272.7		11/2"	100	66	3



Project Blue Jay

1953 Permafrost Investigation

		·				LA	BORA'	TORY		TES1	ř l	DATA					
	Density	M. C.	Comp	Mes.				PER	ENT	FIR	VER						
	Be./bu.ft.	%	%	Size	1 1 2	\$	3 0	No. 4	Na. 10	No.20	No.40	No.100	No.200	02mm	LL	P.	
base inited.	155.7	2.7	100+	2"	87	68	50	40	30	.20	12	ج	3				
elly es ice.	/38.5	6./	96.3	2"	96	80	66	57	51	43	35	17	9	4	;		
aales.	M2.3	3.8	100+	5"	87	76	64	54	44	34	22	7	3			f : ! : :	
ray es up		4.4		2"	87	63	46	36	29	21	/3	5	3				
lany Lany Many ive ive less, =		16.0		2"	78	63	57 68	44 58	38 52	29 44	22 38	13	// 24	8	16	/3	
ered 14" 1. Ice	68.0	50.5		2"	35	8/	72	62	55	47	4/	30	24	15	17	/3	
lume.	85.4	35.2		s.	97	93	81	73	65	58	49	34	26	15	17	14	
. Many 1/4"± lume	83.6	34.9		2"	77	69	59	51	14	37	29	/9	15	10			
	88.5	31.4	-	2"	78	70	6/	56.	.50	44	37	21	15	9			
enses ed stones	45.7	31.8		1 1/2"	100	0 6	77	ce	61	51	15	33	26	14	17	12	-
	52.0	76.1		11/2"	100	87	77	68	G/	5.5	16	33	26	15	17	/2	,
rs direy ad site	18.7	272.7		1/2"	100	56	58	18	12	35	29	10	"	9			

3

Sneet 1 of 2

Date: DM-3-31-53: TP4-15-53 to 4-18-53

Submitted by: S. B.

T	(ATA	· · · · · · · · · · · · · · · · · · ·					0	Source	
IN	£R							Specific	of	Remarks
5	No.40	No.100	No.200	02mm	LL	ė.	، د	Gravity	Material	
	12	5.	3						So. River	Simples Athron, QE'-QQ, and K.L.10'- 12', are all frozen chunks from EESE pit.
	33	17	9	4				2.86		Source of material possibly "N" Terrace or area around F" Quarry.
	22	7	3"					ı	No. River	Max. size cobble = 6".
	/3	5	3						"F" Querry and No. Mountain	Max.size of quarry rock 2 3.0°. sample Consists of dierite sand and gravel size quarry rock. Meterial too frience to run frozen density,
	22	/3	//	8	,				Native Soil	Native soil at 5.7'. Change from fill to native soil is sharp.
	36	29	24	14	16	13	3		Native Soil	
	41	30	24	15	17	/3	4	• • •	Native Soil	
	49	34	26	15	17	14	: 3	2.68	Native Soil	
	29	19	15	10					Native Soil	Care proken, but good - 75% recovery.
	37	21	15	9				-	Native soil	
	15	33	26	14	17	12	ج	2.75	Native Soil	Test pic completed at 12.0'.
	46	33	26	15	17	12	5		Native Soil	Core good -100% recovery
	29	10	"	9					Notive Soil	Core good - 75 % recovery

Mercalt & Lady o

Hole No. TR #7.

Lec: Sample No. 36 - S

Lett.	compared 36) - 3						<u> </u>	Ľ
40						-		LA	80
100	Graphic Lag	Description & Classification	Density Ba/cu ft.	M.C %	Comp.	Mes. Size	11	Ŧ	П
Ν	ICE ICE	Ice = 90% t by volume. Ice is stratified, loyers of clear, caloriess ice with atternating loyers of dirty ice containing suspended particles of gravel, sand, and site.	18.7	272.7		/ <u>%</u> "	106	.66	-3
1-18.5- ▶ P	GP-GM	Same os"N" - ice = 35% t by Volume	10.8	195.Z					
ğ	5. p. GW	Grey, bedly frectured, dwritt rock. Ice in the form of wedges between all the procen foces. Broken foces are matching, and separated by ice.	lis:9	18.6	·	112"	100	95	
							1 ; o b		: .
-						-			
• •								* * * * * * * * * * * * * * * * * * *	
								7	
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METCOIT & Eddy and Alfred Hopkins & Associates

Project Blue Jay 1953 Permatrost Investigation

)	1333 I WINDIT OF INTESTIGUION													
						LA	BORA	TORY		TEST		DATA			
	Density	M.C.	Comp	Max				PER	ENT	FI	ER				
	be fou ft.	*	%,	Size	11	1	ł.	Na.4	Na 10	Na.20	No.40	No.100	No.200	.0244	LL.
ed, loyers of yers of dirky of sand, and site.	18.7	272.7		/½"	100	66	56	18	42	35	29	18	"	9	
	10.8	195.2													
in the form of ten foces are	// 5 :9	19.6		11/2"	100	95	59	32	/9	"	8	4	3	~	
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			The state of the s												
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okins & Associates

Sheet 2 of 2

Date: DH 3-31-57 TP 4-15-55to 4-18-53

The second secon

tigg	tion						Date: DH 3-31-57 TP 4-15-53 to 4-18-53 Submitted by S.B.			
ES1		DATA			,~=.				Source	
F11 a 20	_	No.100	No.200	.02 ma.	LL.	PL	P	Specific Gravity	of Man_vial	Remarks
5	29	18	"	9		-	a day		Native Soil	Core good - 75% recovery
						e de de la companya d	: !	•	Native Soil	Core good - 100% recovery Insufficient material to run laboratory tests.
,	8	4	3			•	i	! ,	Native Soit and for Bed Rock	Core good - 100 % recovery. Probably the upper zone of diorite bed rock.
1		! !				i :	:			Hole completed at 16.8 ft.
		: : :					• • •	: :		
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		; !				: :				
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Metcalf & Eddy ar

Hele No. TR#8 Location Runway: Sta. 69+13, 50'Lf. & Lob. Sample No. 35 - 5

1953 Perr

2000	authorise service								
15	Sraphic Log							LA	ВО
10	Graphic Lo	Description & Classification	Density	M C.	Comp	Max.		3-	-
8			be/cuft	%	%	Size	地	₹	• •
0.8'-		Bituminous Concrete							
A	GP NP	Penetration Mecedam Light brownish gray, minus 2%, crushed gravel base course. No visible ice, a trace of frest-poorly bonded.	155.7	2.7	100+	2"	87	68	50
В	SP-SN IC-IX	sand with a truce of organic matter, A rew harely visible	/38.5	6.1	96.3	2"	96	80	66
C	SP IC	Gray, poorly graded, gravelly sand with cobbles, Some of the gravel coated with a very thin film of ice.	/42.3	3.8	100+	2"	87	76	64
D	ROCI GW NP	Diorite querry rock, Choked with brownish gray diorite Sand. Quarry rock = 80% t by volume. Voids up to 6" are common due to bridging of large Lotties. No visible ice - friable.		4.4		2*	87	63	Št.
-3.7' E-6.0'-		Grayish brown, poorly graded, silty, sandy gravel. Many irregularly oriented ice lenses and masses to he. Ice = 20 h t by volume.	117.2	15.0		2"	78	69	57
F. 2.0	GM II	Grayish brown, silty, sandy gravel with cobbles. Many irregularly oriented ice lenses up to 12", and massive ice around the cobbles. Ice is hard, clear and colonless: 30% to y volume.	74.9	42.8			9/	76	68
G	SM	Gravish brown, silty, gravelly sand with scattered cobbies. Many irregularly oriented ice lenses up to 4". and some massive ice, mostly around the gravel. Ice is clear, colorless and hard = 40 % t by volume.	68.0	50.5		2"	95-	81	12
H		Same as "6", with gray mostling. Ice = 30% t by volume.	83.4	35.2		2"	97	93	81
ال ال	1/X1H	Brownish gray, silty, clayey, gravelly sand with cobble Many small ice lenses up to 14". Lenses run in 211 directions and form an intricately laced pattern. Ice = 4070 ± by volume.	5B.3·	62.9		3/4"	100	100	90
K	15-1	Same as "J", but color is grayish brown.	618	58.8		1/2"	100	89	80
L	GM-0	Grayish brown, silty, clayey, sandy gravel with Cobbles. Many thin ice lenses up to he thick. Lenses are parallel and 19 to 74 apart, gives soil laminated appearance. Also massive ice around the gravel. Much of the ice was melted, and outside of circ combles		34.8		11/2"	100	89	77
M -12.0'-	SM-5	thick lances the in all directions and form intringed.	55.1	69.7		1 1/2"	100	36	79
2	5 (10/17)+/(3-12-1	Gravel, sand, silt and possible clay with much ice. Badly fractured diorite rock at bottom of hole. Sample completely thawed and unreliable.							

P

Project Blue Jay

1953 Permafrost Investigation

	2					LA	BORA	TORY	+	TEST		DATA			
	Density	MC	Cimp	Mana				PER(ENT	FII	IER				
	Be/cuff	4,	%	Size	14	* * * * * * * * * * * * * * * * * * *		No.4	Na 10	No. 20	No.40	Na iOG	No.200	.02 mm.	LL
iati gravel base e-poorly bonded.	<i>\$5.</i> 7	2.7	100+	2"	87	68	so	40	30	20	12	5	3		
tly silty, gravely ten barely visible plad with ice	138.5	6.1	96.3	2*	36	80	66	57	51	43	33	17	9	4	
ith cobbles, some film of ico.	/42.3	J.6	100+	2"	87	76	64	54	44	34	22	7	3		
ownish grøy Vume. Voids up of lørge cattles.		4.4		2*	87	63	46	36	29	21	18	5	3		
, sändy gravel. and masses	117.2	16.0		2"	78	69	57	44	38	29	23	/3	i , //	. 8	
cours. Many and massive ice and colonless :	74.9	12.8			9/	76	68	58	52	44	30	! ! 29	` 24	14	: - 16 i
vita scattered lenses up to M. lense gravel. Ice by volume.	68.0	50.5		2"	95-	8,	72	62 ;	ss	47	i 41	: . 30	24	/ /5-	17
30% t by velume.	83.4	35.2		2"	97	93	81	73	65	50	19	34	26	15	17
sand with ceable es run in all aced pattern.	58.3	62.9		3/4"	100	100	90	81	70	€2	53	39	3/	17	/8
prown.	E1 B	58.8		1/2"	100	89	80	69	60	52	44	3/	24	14	17
ravel with "thick. Lenses Soil lamnated of the gravel Ve of cure counting		34.8		11/2"	100	89	77	63	56	45	10	36	32	24	22
velly sand with oses up to ye" form intricately	55.1	69.7		172"	100	86	79	69	61	53	46	34	26	15	16
with much ice m of hole. Sample															

D

Date . PH 3-30-53: TP 4-15tole-55

Submitted by: 5.B.

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									1	
EST	Γ ;	DATA							Source	
FI	MER							Spec fic	of	Remarks
20	No.40	No iOC	Ng.200	.02 mm	LL	PL	Ρ	Sravity	Material	
0	12	5	3	-				<u>.</u> !	So. River	Semples A thru H .O.6'-29' ere all frezen chunks from test pit.
13	33	17	9	4		:	<i>:</i>	2.86		Source of material possibly "N" Terrace or area, around "F" Quarry
74	22	7	3				!	· · · · · · · · · · · · · · · · · · ·	No. River	Max size cobble =6".
?/	/8	5	3			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		•	"F" Querry end No. Mountain	Max. size querry rock = 3't. Semple. Consists of divite send and gravel size querry rock. Meterial too friente to run frozen density.
9	22	/3	: , // :						Native Soil	Native soil at 5.7. Change from fill to native soil is swarp.
4	30		24 !	14	: · <i>16</i> :	13	3	•	Native Soil	
7	41	; <i>30</i>	24	15	. /7	: / 3 :	! 4		Native Soil	NOT REPRODUCIBLE
8	19	34	26		17	14		2.68	Native Soil	, alt
2	53	39	31	17	/ 8	: : /4 :	1		Native Soil	Core partially thawed, as withessed by peoples on outside with large voids around them. M.C. and dansity results unreliable.
2	14	3/	24	14	17	/3	4		Native Soil	Same
,	10	36	32	29	22	/6	6	1	Wative Soil	Core badly thewed M.C. unreliable. Impossible to run frozen density, because all but center of core crumbled.
3	46	54	26	15	16	//	5	: : :	Native Soil	Core good-Surfaces slightly thawed-
						<u>.</u>		:	Native Soil	Only recovery in this zone was 3" of crimbled core of which about 75% was badly frectured diorite. Probably hit diorite at 15.8'z and material above was mostly ite that theward See Samples N.P.G. Log TR* 7. PLATE AI3

Hote No. TR#9 Leceller Runway: Sts. 91+00, L. Leb. Sample No. 23-5

1953 A

										=
2	٤								LA	Æ
. 3	Brankic	Log	Description & Classification	Density	MC	Comp.	Mes			
13		-	<u> </u>	BE ALL	% ,	16	Size	14	i	
			Bitumisous Concrese							T
A	200	G	Cuttings are gray and brown with asphalt. Top 3" is adphalt pavement overlying 6" of minus 62", crushed gravel base course		ルヴ				*	
E	1.5	G #	Cuttings are grayish brown, clean, well graded, sand max size : 12 . No yislate ice. Sandy gravel or gravelly sand with comples.		2.1					
ŀC	<i>-</i>	\$	Cuttings are grayish brown mostly med to fine . Sand-Imax, size 2 %. About 35% of the cuttings aggest to be disrice. No visible isa. Sandy grayel or gravelly sand. Also same disrite quarry rock between 2.5 and 20.	؞ؙ	l•2					
C	0'		Custings are mostly gray diorite, graded from medito fine Sand with a few coarse chips-mari size = ½"		2.0					
E	. \$4. 10.	OCK and	Same as Da		2.7					!
F		5 & G	Same as 'D"							
7.0	19:1		Same es "D"		2.8	e e				-
1	0		Same as D		3 .5					
9,		G or SM	Cuttings are brownish gray, well graded from coarse sand to silt-max. Size a 3/84. A few chips of dionita. Slightly Silty sandy gravel or gravelly sand with couples.		3,4					
K	Ø-1.1\ 1 ·	S or	Cuttings are light brown, graded from coarse sand to Sile-max. Size 244 sieve. Slightly silty gravelly sand or Sandy gravel with a small amount of organic matter.		4.3					-
L -//.	0	SM .	Same as "K" - color grayien brown.		3.9					
N -/2		SM NW	Light brownish gray, Silty, gravelly sand with a trace of organic matter. No visible ice-well bonded.	/35.9	5.4		1"	100	89 ,	
13	0	G or SM	Cuttings are gray, mostly uniform coarse sand with some fine sand and silt. Slightly silty sandy gravel with coboles. No usible ice, cuttings are quite wet.		6.6					
F		GP II Ved	Brownish gray, poorly graded, sandy gravel 50% to the gravel is district. Surface of core completely thewed, Showing loose etones and large voids. Center of core is soft tice. Many pockets of massive ice up to 40" and many icreaviery oftential ice isneas.		19.1		2"	7/	36	



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					13	37	GIIII	III VOI							
						LA	BORA	TORY		TEST		DATA			
tian	Density	M.C.	Come	Mex				PER	CENT	FII	IER	·			
	Be Acu Pi		%	Size	14	\$	1	No 4	No.10	Na.20	No.40	Na.100	No.200	.02 ma	
vien asphalt. Top 19 6" of Minus &		1.7					=				:=				
leen, well graded. ice. Sandy gravel	3.	2.1													
astly mad to time , i the cirtings appeal by gravel or grovelly in between as and 25.	÷	l•2													
e, graced from med. ips-mar. Size = ½"		2.0			:		: !								
·		2.7 ~			i i .			•				. -			
					•										
		2.8		-											
		3. 5													
well graded from: 3/8". A few chips ravel or gravelly		3,4								•					
ded from coarse re: Slightly silty with a Small amount		4.3													
wa.		3.9													
relly sand with a visible ice-well	/35.9	5.4		,"	100	89.	77	70	64	54	45	31	25	14	,
torm Coarse Sand lightly silty Sandy tings are quite wet.		6.6												•	
sandy gravel 50%. I care completely thowas, da. Center of core ine ice up to 44" and		19.1		2"	7/	36	26	21	17	13	10	6	4		

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Sheet 1 of 2

Date: DH 3-27-53: DH 4-6-58

Submitted by: S.B.

	177									Submitted by . S.B.
\$1	}	DATA							Source	
FIN	ER	•						Specific	of	Remarks
20	No.40	Ma.100	No.200	.0200	LL	PL	Pli	Gravity	Material	
									No. Rivêr	Sample 'A' includes both the asphale parestant and base course. Cuttings from the cone rotary rock bit.
			•					•	"H" Terrace	Cuttings from tri-cone retary rock. Rig Douncing ove to coarse gravel and/or coboles.
								! ! : :	'H"Terrece and F"Quarry	Same
								•	F"Querry	Same · drilling very hard
							-	8 0 4 : 1 2 3 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	F" Querry	Same - drilling very hard
									F" Quarry	Same-drilling very bard
									F" Quarry	Same-drilling very hard
									F" Quarry	Same - drilling * Very hard
									Local Borraw	Same
					;				Local Barrow And/or Notive Soil	Cuttings from coring bit. Cored thry this zone, but no core recovered. Hard to tell where fill ends and notive soil starts. Estimated depth to native soil is 9.5°.
									Native Soil	Cuttings from coring bit-no core re- covered.
	45	3/	25	14	14	thon pl	estic	2,69	Native Soil	Care badly broken - 75% recovery. About 3" of salid care, rest crumbled and mostly gravel. Tests run on 3" solid care. Sample may not be representative.
								1	Native Soil	Cuttings from core bit-no core recovered.

Native Soil and Bed Rock

PLATE A14

Core badly crumbled and thawed- 7570 recovery M.C. unreliable. Hat the upper surface of diarite bed rock at 18.3'±.

Hale No. TR#9
Location Runway: Sta. area, &
Lab. Sample No. 23-5

	emple No. 2:	[**]					13	<u> </u>
\$ £		-						LA
i	Graphic Log	Description & Classification	Density	M. C.	Comp.	Max		
			See /cu ff	%	%	Size	14	ì
Q		Gray silty sandy gravel The material is all broken up diorite. Many ice crystals and irregularly entented ice lenses up to thick. Ite is clear, couriess and bards	75.3	45.4		1"	100	83
	1 2 3 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	\$0% to by volume Bodly frectured charite rock, with ice in the frictures. Ece is clear, coloriess, and hard. Cuttings are gray, mostly med to fine soul A few	/43.8	11.1				
.6-	V. V.	Cuttings' are gray, mostly med to fine soud A few chips of ice. Badly fractured diorite with ice in the fracture planes		8.4				
ر	,	Same as "T"-no ice, not as badly fractured.		4.3				
7.0	200	Cuttings are gray, mostly medium to fine sand- max size = 40° No visible ice, very dry. Rock now solid digrite.		1.5				
0	V	solid diarite.					<u>.</u>	į
٧	***	Same as V		3.7				,
	Completed						1	•
								:
						,		
						22.0		
								*

Project Blue Jay 1953 Permafrost Investigation

				,	LA	BORA	TORY		TEST	r 1	DATA						
Density	M.C.	Comp.	Mes				PER	ENT	Fil	ER				ž			S
se./cuff	*	%	Size	14	7,	3"	No 4	No.10	Na.20	No.40	Nc 100	No.200	.02 mm	LL	Ρį	P !	S
75.3	45.4		1"	100	85	63	54	16	36	30	25	19	10.				
4 3.8	 																
	8.4																•
	5.7															i i	
	4.3						<u>i</u>							i !	1		
		i				!				ì		•	<u>.</u>				;
	1.5	İ		;] 			[ł				<u> </u>	•	<u>!</u> !	<u> </u>	\$
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ins & Associates

Sheet 2 of 2

Date . DH 3-27-53; DH 4-6-53

. Submitted by: S.B.

A DESCRIPTION OF THE PROPERTY

S		DATA						-	Source	
F 2	NER MAG	Nc 100	N. 200		L.L.	Pi	PÎ!	Specific	of	Remarks
	MQ.4U	AC NO	MB 200	.02 mm				Gravity	Material	
	30	25	19	10.					Bed Rock	Cere good - 100% recovery
						:			Bed Rock	Core good- 100% recovery. Not broken up chough to get an M.A.
										Cuttings from tri-came rotary rock bit. Rig bouncing padly
									Bed Rock	Same - rig bouncing slightly
									Bed Rock	Same - rig running smoothly, drilling very hard.
		·							Bed rock	Same Hole completed at 12.0'
					ļ	:				
		-								
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1							!			
		į								

Metcalf & Eddy

Hole No. $TR^{\#}/0$ Location Runivay: Sto. 9/+/3, £
Leb. Sample No. 22-S

- CO.	SO MA	700 6								=
1 5			·						LA	В
10	Graphi	ic Log	Description & Classification	Density	M.C.	Comp	Mer.	1	35	
-			Bièuminaus Concrete	Ba./cu.ft.	*	*	Size	1ģ	-	H
A	Ο.	G	Cuttings gray and brown, graded from % to fine sand-max. size = 16" Minus ,2.12" croshed gravet base course.		2./					
В	0	G	Suffings are gray, graded from ped gravel to rive sandwhar. size : 46%. Ne visible ice. Sandy gravel or gravelly sand.		1.8					
C -3.0'-	6	5	Same as "B" -maxisize = /2 ·		2.2					
D.	0		Cuttings are gray mostly med and fine sand-man size = 14". About 30% diorite. No visible ice. Sandy grand or gravelly cand with diorite quarry rock.		1.8					
E.	100	ROCK and G or	Cuttings are gray, mostly med and fine sand with a few coarse chips-man. Size = 34". About 30% appears to be diorite. Ne visible ico. Diorite quarry rock choked with sand or graver.		2.3					
F			Same as E"-abeut 75% diorite		2.3.				*. 6 2 3	
G -7.0'-	6.0		Cuttings are brown, well graded from coarse to fine sand-mar. Size = 14". No visible ICE. Sandy gravel or gravely sand with cobbles.		4.4					
H -8.04	8	G or S	Same as G"-color grayish brown		5.0					
J			Same · as "G".		3.8					
10.0			Cuttings are grayish brown, graded from med. Sand to Silt with a few coarse chips and a small amount of organic matter. No visible ice. Silty sandy grayel or silty gravelly sand with a small amount of organic matter.		4.3					
L		GM or SM	Same as "K" - less organic.		3.5	Bertinen at American				
-12.0 ² -		GP 15-11	Brownish gray, poorly graded, sandy gravel. Many Ice lenses up to 12" thick and a few pockets of ice up to 1". Ice is clear coloriets and hard < 25% t by volume. About 50% of the gravel is angular divite fragments.	117.6	/6.4		142"	100	55	44
N	7.9. 0.0	GW II	Brownish gray well graded, sandy gravel. The sand is decomposed and weathered diorite, while the gravel is badly fractured diorite. The upper zone of diorite bad rock. Ice is slightly cloudy and wedged between the fractured diorite = 40% t by volume.	92.8	31.3		z"	87	65	5,



Project Blue Jay 1953 Permofrost Investigation

						LA	BORA	TORY		TEST	r I	DATA					
,	Density	M.C.	Comp	Mos			T	PER		_	VER		·				
	be foult.	76	%	Size	12	\$.	3	No 4	Na.10	Na.20	No.40	No.100	Wo 200	.02 mm.	LL	PL	P
10 W50.		2./															
nye H		1.8															!
		2.2															
work.		1.0															
d re-		2.3													i ! !		
		2.3.				\$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$											
ine		4.4				Appendix as single or as page of						1	:	: : :	: : •	i :	
		5.0										 	9		} !	i i	
		3.8															
ount		4.3															
		3.5															
ny ume.	. 117.6	16.4	1	142"	100	55	12	28	23	20	15	7	4				
5.													1				
4	92.8	3/.3		2"	87	65	51	42	3/	21	16	8	4	2			

ins & Associates

Sheet / of 2

* Date: DH 3-27-53: DH 4-6-58

Submitted by: S.B.

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\$1		DATA							Source	
~	ER							Specific	of	Remarks
0	No.40	Na.100	Ma.200	.02 mm.	LL	PĽ	Pi	Gravity	Material	
									No. River	Samples "A" thru"L", Q3'-18.0', consist of Cuttings from tri-cone retery rock bit. Rig bouncing badly
									"H" Torrace	Same
								ı	"N" Terrace	Same
									"N" Terrace and "F" Quarry	Same - hit quarry rock between 3'and
									F" Quarry	Rig bouncing badly - drilling very hard
									"F" Quarry	Sema
				: :	•				La de la companya de	Rig Douncing - Sourse of maserial un- known, possibly local borrow.
					İ					Same
					1			•		Same
									Native Soil	Same - hard to tell where till ends and varive soil begins Estimated depth to native soil = 9.0'
									Native Sail	Rig bouncing slightly
									A/sailer Beil	
	15	7	1						Native Soil and Bed Rook	Some - Estimated depth to start of diarite ped rack = 12.7'. Core good-100% recovery
	16	8	4	2					Bed Rock	Rig bouncing badly. Core good-100% recovery.

Metcalf & Eddy

Hole No. TR# 10 Location Runway: Ste 91+13, & Lob. Sample No. 22-5

•							L
Graphic Log	Description & Classification	Density the /cu ft.	M C.	Comp %	Max. Size	14	*
O O GW	See Sample "N", sheet 1	92.0	31.3		2"	87	65
GP II	Badly fractured diorite rock. Ice along the fracture planes. Ice = 10% t by volume.		7. 8		Z"	83	42
G	Cuttings are gray diorite, nastly med sand in size. A few small chips of ice. Badly fractured diorite with ice in the fracture planes.		10.4				
***	Same as "Q" - rock less finituite.		3.8				
ROCK						1 1 •	: : :
	Same as 'Q" - no ice , solid rock		1.7			! ! !	
Completed				•			•
						*	! :
				•			•
							!
				!			
				1			
							\$ 1 1 2
	\bigcirc						

Project Blue Jay

1953 Permafrost Investigation

						-	CITIC	1100	3111	31.2				~~	
						LA	BORA	TORY		TEST	7	DATA			
	Density	M C.	Comp	Moz	[PERC	ENT	Fil	NER	-			
	Be/cuft		%	Size	14	3	3"	Na 4	Na iO	No.20	No.40	No 100	No.200	-02 e/m	LL
	92.9	3/.3		2"	87	65-	51	42	31	21	16	8	4	Z	
lang the fracture		7. 8		2*	83	42	32	26	20	14	"	6	3		
and in 5120. A few with ica in the		10.4													
*		3.8			•	•					:				•
		:				: !	!						!		
		1.7			1	į	!								
		1 de 1			!	•	į į	+			:		:		
,		!			•	• •					į			i !	
					•	:		1			· · · · · · · · · · · · · · · · · · ·			! !	
		1			!	1				•			1		•
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			į												
			! !												
							1								
					<u> </u>		12		<u> </u>						

Sheet 2 of 2

30	tion									Ogte.DH 3-27-53: DH 4-6-53 Submitted by: S.B.
ST		DATA		ب واشاری استان به د		_	·	T	Source	
-	ER No.40	No.iOO	No 200	Q2 elm	ŁL	Pi	Pi	Specific Grovity	of Material	Remarks
1	16	8	4	2		!	i	†	Bed Rock	Core good -100 % recovery
	"	6	3						Bed ROCK	Core crumuled - 75% recovery.
						:		: :	Bed Rock	Cuttings from core bit. No core recover Rig bouncing badly, drilling hard
:		<u> </u> - -			: :		• •	:	Bed Rock	Same - rig bouncing slightly.
		sample dept sets of sample sets		e menge - statute - statute statute en	1		7 1	:	Bed Rock	Cuttings from tri-cong rotory rack bit Rig running smoothly - arithing very hord
: : :										Hole completed at 19.0'
•		•	!	• •	•	•				
-:					• • • • • • • • • • • • • • • • • • •	:				
•			:			; ;		•		
			; :					i		
1								:		
								· dalling a difference of the second		
								:		

PLATE A17

Hole No. TR*// Location Runway: Sta. 93+50, & Lab. Sample No. 17-5

1953 P

	Graphic Leg		LAI					
Semple N B Depth								
			Density bis/cu ft	M C %	Comp.	Max. Size	14	<u>\$</u>
- asi		Bituminous Concrett						
A0.0'-	G G	Cuttings are brownish gray, graded from pea.grand to find sand No visible ice. Minus 215", crushed grand base course.		1.4	 - -	• •		
B	G	Custings are light brownish gray, mostly med to hee sand-max size = 1/e 1/o visible ica. Sandy gravel or gravelly sand with scattered cobbles.		1.7				
С	S	Same as "B".		2.1				
D -4.0-	ROCK	Cuttings are gray, graded from coarse to fine sand- mar. Size = 1/2". About 75% of cuttings are dignite. No visible ice. Dignite quarry rock choked with sand or gravel.		2.2				
E -so-	G 6 5	Same as "D" - about to % diorite		2.6	· · · · · · · · · · · · · · · · · · ·		! : !	
F		Same as "D" - about so % dionite		2.2	•		:	
G	©: * ²⁰ : G	Cuttings are light brownish gray, mostly madisand to site max size = 48". No visible ice. Sitey sandy gravelly sand with scattered cooples.		3.4			:	1
H.	ĞМ	Same as "G", max. sixe = 1/2"		4.3				
J -90'-	GM	Same as G", but more silt		3.8				
K -/00'-	SM	Same as "J"		3.3				
_	5M IX-IC	Grayish brown silty, gravelly sand with cobbles and organic matter. Many small ice crystals, and all the gravel is coated with a film of ice, = 10% t by volume.	/38.2	7.3		1"	100	95
-12 0 ⁻	GM IX-IC	Same. as 'L" - silty sandy gravel	136.0	7. Z		2"	96	81

Project Blue Jay 1953 Permafrost Investigation

				عبرية فالأسوع			CTITIO	1103	11144	ATTA!	11.0-1					
	•					LA	BORA	TORY		TEST		DATA				
	Density	MC	Comp	Mgr.				PERC	ENT	FIR	ER					
	bs./cu ft	46	%	Size	14	÷	13.	Na 4	No. 10	No.20	No.40	No.iOC	No 200	.02mm.	LL	
ves gravel to yel base course.		1.4			•											
y med to fine y grovel or		1.7														
		2.1														
to fine sand- diorite. No ich sand or		2.2				· .										
		2.6			! : :					\$		j 				
		Z. Z														
tly med. sand Sitty sandy red cooples.		3.4			1							!				
		4.3														
		3.8	• • • • • • • • • • • • • • • • • • •													
		3.3														
iti cobbles crystals, a film of ice,	/38.2	7.3		<i>,</i> "	100	95-	85	75	67	59	51	36	27	12		n
	136.0	7. 2		2"	96	81	66	55-	50	14	38	27	21	9	2/	,

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igation

Date: DH 3-20-53: DH 4-5-55

Submitted by: S.B.

,										
EST	۱	DATA							Source	
FIR	ER							Specific	of	Remarks
20	No.40	No.iOC	No 200	OZ MIRL	LL	P	Pi	Gravity	Material	
						-				· Samples A thru K", 0.3'-10', consist or Cuttings From tri-cont retery rock bit.
									No. River	Rig Douncing
				!			,)	·	
									"H" Terrece	Same
			٠						H"Terrace	Same
								· ·	"F" Quarry	Same
								-	F"Qverry	same
									F" Quarry	Sam e
									Local Bornow	Same
									Local Borrow	Same
									Local Borrow	Søme
									Lacel-Barrow	Same
	51	36	27	12		ROA	O/ds£iC		Native Soil	Cort badly broken - 40 % recovery Native Soil Starts between 10'and 11'.
	38	27	2/	9	21 .	13	ع	2.57	Native Soil	Core badly broken - 50 % recovery

PLATE AIS

Hole No. $TR^{\#}il$ Location Runway: Sta. 93+00, £
Lab. Sample No. 17-5

1953 F

Description & Classification			Γ.	1	Γ	
Otochphon & Chamber	Density Be/ou ft.	M C.	Comp %	Mex Size	14	1
Cuttings are brownish gray mostly fine sandwith some Sire and a trace of organic master. No visible ice. Silty gravely sand or silty sandy gravel.		3,9				
Cuttings are brownish gray, clean well graded Sand with some coarse chips-max size = ½. No visible ICE Sandy gravel or gravelly sand.		2.1				
Cuttings are brownish gray fine sand with some sitt and a trace of Organic motter. No visible ice. Silty sand.		7. 2				
Same as Q		6.6				
Cuttings are trownish gray, mostly fine sand and sile. Cuttings very wet, and many small chips of ice. Silty gravelly sandy sile with much ice.		31.2				:
Some as T" -no visicie ice , a few chips of diòries .		13.4			! !	
Cuttings are brownish gray mostly med to fine sand with some sist. About 50% disrite. No visible ice. Badly fractured disrite rock with some sist and sand in the fractures.		4.2	And the second control of the second control		To the state of th	
Cuttings are gray, uniform med to fine sand. Solid diorite rock.		0.9				
Same es "W"		1.0			ne e eren en en e	
	Cuttings are brownish gray, clean well graded sand with some coarse chips-max size = 1/2. No his like ICE Sandy gravel or gravelly same. Cuttings are brownish gray fine sand with some site and a trace of organic maeter. No visible ice. Silty sandy gravel or sitey gravely same. Same as Q Cuttings are knownish gray, mostly fine sand and sile. Cuttings very wet, and many small chips of ice. Silty gravelly sand or gravelly sandy sile with much ice. Some as T " no visible ice, a few chips of divide. Cuttings are brownish gray, mostly med to fine sand with some sile. About 50% divide. No visible ice. Badly fractured divide rock with some sile and sand in the fractures. Cuttings are gray, uniform med to fine sand. Solid divide rock.	Cuttings are brownish gray mostly fine sand with some size and a trace of organic matter. No visible resilty gravely sand or sury sanay gravel. Cuttings are brownish gray clean well graded sand with some coarse emps-max size the . No visible reasons with some coarse emps-max size the . No visible reasons and a trace of organic matter. No visible reasons with sand a trace of organic matter. No visible reasons gravel or sury gravely sand. Some as Q Cuttings are trownish gray mostly fine sand and size. Cuttings very wet, and many small chips of reasons size. Sitely gravelly sand or gravelly sandy size with much rece. Some as T "-no visite reasons are they chips of divide. Cuttings are brownish gray mostly med to fine sand with some size about some with some size about some with some size and sand in the fractures. Cuttings are gray, uniform med to fine sand. Cuttings are gray, uniform med to fine sand. Cuttings are gray, uniform med to fine sand.	Cuttings are brownish gray, mostly fine sand with some sins and a trace of organic matter. No visible ice. Silty gravely sand or silty sandy gravel. Cuttings are brownish gray, clean well graded sand with some coarse chips - max size z 1/2. Its visible ice. Sandy gravel or gravelly sand. Cuttings are brownish gray fine sand with some silty sandy gravel or silty gravelly sand. Cuttings are brownish gray mostly fine sand and silty sandy gravel or silty gravelly sand. Same as Q Cuttings are trownish gray, mostly fine sand and sile. Cuttings very wet and miny smbil chips of ice. Silty gravelly sand or gravelly sandy silt with much ice. Same as T " -no visitic ice, a few chips of divite. Cuttings are brownish gray, mostly med to fine sand with some silt. About 50%, divide. No visible ice. Badly fractured divite rock with some silt and sand in the fractures. Cuttings are prownish gray, mostly med to fine sand with some silt and sand in the fractures. Cuttings are gray, uniform med to fine sand. Cuttings are gray, uniform med to fine sand.	Cuttings are brownish gray, mostly fine sand with some size and a trace of organic mister. No visible resistly gravely sand a trace of organic mister. No visible resistly gravely sand or site, sandy gravel. Cuttings are brownish gray, clean well graded send with some coarse chips—max size = ½. 1% wisible resist and a trace of organic motter. No visible resist and a trace of organic motter. No visible resistly sandy gravel or site, gravelly sand. Same as Q Cuttings are brownish gray, mostly fine sand and size. Cuttings are brownish gray mostly fine sand and size. Silty gravelly sand or gravelly sandy site with much resist. Same as T "no visible resist and side shape of resist. Same as T "no visible resist and side shape site with much resist and site. About so h divide. No visible resist and sand with come site. About so h divide. No visible resist and sand with come site. About so h divide. No visible resist and sand with come site. About so h divide. No visible resist and sand in the fractures. Cuttings are prownish gray mostly med to fine sand. Cuttings are prownish gray mostly med to fine sand. Cuttings are gray, uniform med to fine sand. Cuttings are gray, uniform med to fine sand.	Cuttings are brownish gray, mostly fine sand with some size and a trace of organic master. No visible ice. Lifty grantly famo or sizy sanay grantly. Cuttings are brownish gray, clean well graded sond with some coase chips man size size. No visible ice. Cuttings are brownish gray fine sand with some site and a trace of organic maters. No visible ice. Sity sandy gravel or sixty gravelly fine sand and size. Cuttings are trownish gray mostly fine sand and size. Cuttings are trownish gray mostly fine sand and size. Cuttings are trownish gray mostly fine sand and size. Cuttings are trownish gray mostly sand with much rec. Same as T " no visite ice, a few chips of derice. Same as T" no visite ice, a few chips of derice. Cuttings are brownish gray mostly med to fine sand with some size About 50th diarle. No visible ice. Bodly fractured diarle rock with some size and size sand in the tractures. Cuttings are gray, uniform med to fine sand. Cuttings are gray, uniform med to fine sand. Cuttings are gray, uniform med to fine sand.	Cuttings are brownish gray, mostly fine sand with some sire and a trace of organic mother. No visible religious arm course chips fine sand with some course chips fine sand with some course chips fine sand with some course chips fine sand with some site and a trace of organic matter. No visible ica. Sity sandy gravel or sity gravely sand. Cuttings are brownish gray fine sand with some sity and a trace of organic matter. No visible ica. Sity sandy gravel or sity gravely sand. Same as Q Cuttings are knownish gray, mostly fine sand and size. Cuttings are knownish gray mostly fine sand and site pravelly sand or gravelly sand chips of ica. Sity gravelly sand or gravelly sand site with much lice. Some as T **—no visible ica is few chips of driving. Cuttings are brownish gray, mostly med to fine sand with some site About soft, diarite. No visible ica. Sand in the fractures. Cuttings are prownish gray, mostly med to fine sand with some site About soft sointe rock with some site and sand in the fractures. Cuttings are gray, uniform med to fine sand. Cuttings are gray, uniform med to fine sand.

Project Blue Jay

1953 Permafrost Investigation

						LA	BORA	TORY		TEST		DATA			
9 n	Density	MC	Comp	Max.				PER	ENT	Fil	VER				
	be/cuft.	%	%	Size	14	35	3"	Na 4	Na. 10	Na.20	No.40	No.i00	No.200	.02 mm.	٦
stly fine Sandwith other No visible ice- orel.		3.9				enemies de composition de la composition della c									
in well graded ize = 1/2 . He visible		2.4													
Sand with some .No visible ice. and		7.2				• • • • •									
		6.6			!	; ; ; ;									
ly fine sand and all chips of ice. by sile with much		31.2				1 1				2					
v chips et diòrite.		13.4			!		All the control of th	1							
ostly med to fine arite. No visible th some silt and		4.2				40 to 10 to	Mar fight is glaggering to the agreement			T					
to fine Sand.		0.9													
		1.0													
							B								

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Sneet 2 of 2

Date. DH 3-20-53: DH 4-5-53

Submitted by: S.B.

The second secon

ES	7	DATA							Source	
FI	NER	**** *********************************							of	Remarks
20		No.iOO	No.200	.02 mm.	LL	s (_	F	Specific Gravity	Material	
									Native Soil	Cuttings from care bit. No core recovered.
							1		Native Soil	Some - This material appears too clean to be from this zone, possibly cave in from above.
									Ngtive Sail	Cuttings from core bit. No core recovered.
			-						Native Soil	Same
									Native soil	Same
		:							Native Soil	Same - hit upper surface of diorite bed rock between 19'and 20'
	Andrews of the control of the contro								Bea Rock	Cuttings from tri-cone rotary rock bit. Drilling very hard, rig bouncing bedly.
									Bed Rock	Same - rig running smoothly.
									Bed Rock	Same as above Hole completed at 26.5'
					,		1	0		

Metcalf & Eddy an

Hole No. TR #12 Location Runway Sta. 93+63, £ Leb. Sample No. 16-S

1953 Perr

2	=							,		LA	901
1	3	Grapt	ic Log	Description & Classification	Density	M.C.	Corne	Max.			
3	•				Be /cu ft.	%	% ,	Size	14	<u>x</u>	3
-0.3	7			Bituminous Concrete			1				
A		0	G	Cuttings are brownish gray, graded from to fine sand. Minus 215, crusted graves base course.		29				,	
Е	3	6	G or S	Cuttings are prown, graded from coarse some be- fine sond-max. Size = /4". No visible ice. Sandy gravel or gravely sand with cobbles.		2.7	,	**			1
C).	2 0 0 Δ	ROCK and 5 or G	Cultings are gray, mostly med to fine sand-mun.size z Ye". No visible ice. Divrite quarry rock choked with sand or gravel.		3. 9					
D		V	SM or GM	Cuttings are brownish gray, mostly fine sand to silt. No visible ice. Silty gravelly sand or silty sandy gravel with cobbles.		8.5					
Ε			SM IC	Gray, silty, gravelly sand with scattered cobbles. No visible Ice crystals or lenses, but a few of the stenes are partly coated with a very thin film of ice, well bonded.	144.1	6./		. 2 "	9/	87	80
F	,		GM SM	Cuttings are brownish gray, graded from coarse sand to Sitt-max. size = 1/8. No visible ice. Silty sand with coboles.		4.1					
G-12.	0			Same as "F".		3.6					
H-13.0			GM NW	Brownish gray, silty, sandy gravel with cobbles. No visible ice-well bonded.	144.5	4.9		1/2*	100	86	7/
J -/4 (0'_		GM-Pt NW	Brownish gray silty, sandy gravel with very dark brown peat. Peat = 30% t by volume. No visitle ice, but peat very hard in frozen state-well bonded.	93.7	23./					

Project Blue Jay 1953 Permafrost Investigation

				`		LA	BORA	TORY		TEST		DATA	•			
	Density	M. C.	Comp.	Max.				PERC	ENT	FIN	IER					
	Be/cuft.	%	% .	Size	1	7	10	Na.4	No. 10	No.20	Na.40	No.100	No.200	.02 mm.	LL	PL
om % to ourse.		29	-													
send by: indy graval		2.7														
od – Mea. 142g 2 od: wjéh Sand		3.9	-			·										
and to silt.		8.5									,					
ed cobbles. ew of the im of ics,	144.1	<i>6.1</i>		2"	9/	87	80	72	65	56	46	30	22	/3	18	15
om coarse ice. Sitty oboles.		4.1														
		3.6	1 to													
obbles. No	14.4 5	4.9		1/2"	100	86	7/	58	51	45	37	25	19	11	ور	16
very dark Isiale ice, ed.	93.7	23./						B								

Sheet / of 2

Date: DH 3-19-53: DH 4-4-53

Submitted by: S.B

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ES1	1	DATA						d		
	IER		··········				***************************************	·	Source of	9
20		Na IOO	No.200	.02 mm.	LL	Pλ	Pi	Specific Gravity	Material	Remarks
						-	,	0.00.17		
									No. River	Cuttings from tri-cone rotoxy rock bit. Rig bouncing.
						,			"H" Terroce	Same
									"F" Quarry	Same - drilling hard.
									Local Borrow	Same
6	46	30	22	/3	18	15	3		Local Borrow	Core good - 100% recovery
									Local Borrow	Cuttings from core bit. No core re- covered - rig Douncing
								i i i i	Local Borrow	Same
-	37	25	19	11	ور	16	3		Local Borrow	Core good - 50% recovery
							i	2	Native Soil	Core good -100% recovery. Impossible to run M.A. hydrometer, and Atteberg Limits due to lorge amount of organic matter.
								~_~~		PLATE A20

Metcaif & Eddy or Pro

Hole No. TR # /2 Location Runway Sta. 33+65, £

1953 Peri

Leb. S	emple No. 16	-\$					19	53 P	eri
å ë								LA	BO
Semate Dep	Graphic Log	Description & Classification	Density the four ft.	M.C.	Сотр.	Man. Size	1 2 "	<u>\$</u>	
K	GM NP	Grayish brown silty sandy gravel with a small amount of organic matter and scattered comples. No visible ice-poorly banded.		7.4		2"	93	72	6-
-15.8'- -16.0'-	SM NP	Grayish Drown, Silty, gravelly sand with a trace of organic matter and scattered coopies, also some reddish prown mattling. No visible ice-poorly bonded.		5.8		2"	35	8/	75
М	SM IC	Same as "L" - coating of ice on some of the gravel.	128.4	10-1		e"	96	7'6	66
N.5'-	CW-CM	Dark brown Slightly Slity Sandy gravel mixed with grayish brown silty sand. Scattered scholes and a trace of organic matter. Core is thowad, but not very wet.		7.9		24	69	5/	39
Œ	S.O. CW-CM	Brownish gray, well graded, slightly silty, sandy gravel The gravel is badly fractured diorite, while the sand and silt is badly weathered and decempesed diorite. Harry irregularly oriented ice lenses Ice is clear, coorless, and hard = 30% t by volume.		14.8		2"	9/	72	59
Q	CP ∴ II	Badly fractured diorite rock. Ice is clear, hard, and colorless, and is wedged in the fissures = 20% ± by volume.	118.4	17.1		2"	94	54	33
R -2844	CP-CM	Some as "Q" - more fines	107./	21.6		2"	95 .	62	47
T -25.0'-	ROCK	Cuttings are digrite, uniform med to fine sand in size. Frectured digrite rock.		1.0	Additional distribution on multiples on the day of		Name of the case o		A. A. A. A. A. A. A. A. A. A. A. A. A. A
				THE RESERVE OF THE PERSON OF T					
					Avenue de la constante de la c				

Project Blue Jay

1953 Permafrost Investigation

						LA	BORA	TORY		TEST	1	DATA				
	Density	M.C.	Comp.	Men				PER	ENT	FII	ER					
	Be/out	*	%	Size	14	<u>\$</u>	7,	Na 4	Na 10	No 20	No.49	Na iOO	Mo 200	02 mm.	LL	Pi
å small cobbles.		7.4		2"	93	72	64	56	\$1 ,	45	39	27	20	•		non
a trace of some orly bonded.		5.0		2"	25	U I	75	69	64	56	47	31	19	12	18	17
ne gravel.	i28.4	10-1		2"	96	76	66	59	£3	17	10	25	16	7	23	nen
nised with s and d i, but not		7. 9		2*	69	51	39	33	29	24	.18	10	7	3		
r Sandy ta while decempesed is Ite is		14.8	man alam o a . de de desarrolla de a ante mana	2"	5)	72	59	46	32	21	15	8	5			
clear, hari, es = 20%2	113.4	17.1		2"	94	54	33	24	18	14	//	6	3		M dat o mind tope in w cap	
	107./	21.6		2"	25.	62	47	34	24	/3	14	9	7		• 11 Lan • Calledon Street, and the Calledon S	
sand in		1.0														
								P.								

Snee: 2 0! 2

Date: DH 3-19-53: DN 4-9-53

Submitted by S.B.

	11001		والمراجع والمراجع والمراجع والمراجع والمراجع والمراجع والمراجع والمراجع والمراجع والمراجع والمراجع و					والبوسو بالسرارات	بيوب يجدانه موساسي بادبيراك	Submitted by S.B.
ES1		ATA			_				Source	
F18		Nc.iOO	₩ 200	.02 mm.	LL	Pι	l ∶ p . }	Specific Growity	of Material	Remarks
-	39	27	20	9		non	piestic		Nacive Soil	Core crumbled - 100 % recevery
6	47	31	19	12	/8	1 /7	· /		Meeire Soil	Same
7	10	25	16	7	23	non	riastic		Natire Sail	Core good -50% recovery
,	18	10	7	3			e games o responso.	2.69	Natire Soil	Core broken and thawad - 75% recovery
	15	8	5				Andrew - Control of the Control of t		Bed Rock	Care badly broken and partly showed- 75% recovery.M.C. varellance.
	"	6	3			• • • • • • • • • • • • • • • • • • •	designation from contracts		Bed Roc	Core broken - 50% recovery.
B	14	9	7						Bed Rock	Same
				•	·				Bed Rock	Cuttings from core bit - no core recovered. Rip bouncing slightly - drilling very hard. Hole completed at 250°.

PLATE AZI

Metcalf & Eddy on

Hole No. TTW/
Location South Loop Taxiway, Sta 34+75, 18.75'Lr. &
Lab. Sample No. 26-5

1953 Pern

LIN:	sample No. 2	6-3						30 F	GIII
2 =								LA	BOF
30	Graphic Lag	Description & Classification	Density Be/ou ft	M C.	Comp.	Mox Size	14	Ĭ.	1
-03'- A -1.0'-	GW	Asphalt Pavement Cuttings are gray, mostly well graded sand with a few coarse chips. Minus 2%, crushed gravel base course.		3.6					
В	0.0	Cuttings are light brownish gray mostly med to fine sand-max. Size = 48°. No visible ice. Clean, sandy gravel with coobles.		1.9					
-3 <i>6</i> -	0 G	Some as "B", max. size = %g".		1.6					
D	SM	Cuttings are light brownish gray, mostly fine Sand and sitt-mar. size = 44°. No visible ice. Silty gravelly sand Or silty sandy graval with cobbles.		3.5					
	Completed								

Project Blue Jay

1953 Permafrost Investigation

						LA	BORA	TORY		TEST		DATA					
	Density	M C	Comp.	Max				PER	ENT	FI	IER	·					
	be fou ft	*	%:	Size	14	35	2,	No 4	No 10	Na.20	No.4G	No 100	Ma.200	02 mm.	ш	۰	
ch a few ourse.		3.6															
id. to in,		1.9															
		1.6											- day two - two as a community in				
ne. Silty Wes.		3.5					ed to de la companya de la companya de la companya de la companya de la companya de la companya de la companya			e despite regulario de casa e despite de casa e de casa de cas							
				inch endingsteining an expression or the owner		e sellen er en en entre des eines en en entre en en entre en en entre en en entre en en entre en en entre en e					egicalisa e de casa distribuição de casa de casa de casa de casa de casa de casa de casa de casa de casa de ca		(a) - mir til majatirin namn gra - til samtra stella objektionin ov				
			Transaction of the second of t								eder der eine der der der der der der der der der de		de en en en en				
								3									

gation

Date: DH 3-27-53 Submitted by S B.

ST	DATA							Source	
FINER							S 4	of	Remarks
O No 40	Mo 100	Nn 200	0	u	P	P :	Specific 3/avity	Material	
							3.00.19		
ł	ļ				1				
								No. River	Cutting to the principles of the second seco
1								No. Alver	Cuttings from the cone rotory rock as
	•			!				į	1 1
ļ		1		:					
i	i	ĺ	İ	1.				H TETTECE	Same - rig bouncing due to comples.
;			•	:				İ	
	!	į	į	; 1				1	1 1
	İ	!		!		ł			
į		i	•	•	•	•	}	i I	
ļ.			1	:]	F4*=	Same - rig beuncing badly from 4.5' to 6.0'. Material is mostly cobbles and boulders.
į.	i	:	L	• •		}		"H"Terrace	Doulders.
	• •		į	1	1			•	1
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i		1	<u>:</u>		•				
ļ		į	; ;	•	•			1	•
ļ		1	!	•				LOCAL BUTTOW	Same - rig bouncing slightly
Í	į	:	ļ !	:			1		Sime rig Benefity Grigory
	i	!	ļ. 1	i				1	
	j			:	l		Ì		With a supplement and a C'
			i	i	ļ	1			Hole completed of 9.5'.
1				:					Material placed same time as
							}		TTW2, Should be some.
,							1		
		į					4		
		:					1		
j							1		
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							•	1	
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					L	Ļ	-		PLATE A

Hole No. TTW #2

Location South Loop Texiwey - Ste 94+75, 18.75' Rt. &

1953 Perr

Lab. Sample Na. 27-3 LABO g a Graphic Log Description & Classification Density M C. (comp MOX Da /cu ft % Size Asphalt pavement Grayish brown, well graded, minus alle crushed gravel base course No visible ice, but near frost an underside of CW 50 153.5 3.0 100+ . 94 71 NP stones. Poorly bonded. Brown, well graded, Sandy gravel. No visible ice, but hoar-frost on underside of some of the gravel. Poorly Donded 147.7 3.9 100 + 95 47 7/ CW Ö 0:1 2.0 NP Same as B" 150.Z 100+ 2.3 2" 76 · 0. 51 38 Ò o a CW Grayish brown, well graded, Sandy gravel A few small ice crystals, minus he", and a thin film of ite around some of the gravel Also cobbles. 47 155.9 67 2.5 100+ · IX-IC 6.01 4 0 0.0 Grayish brown, well graded, Sandy gravel with many cobbles Quite bony with some rock to rock contact. CW 2.7 2.. NO K-NP 153.9 1100+ 65 94 44 NO visible ice Grystals or lenses, some gravel partly course with a thin film of ice - soorly bonded. 000 5.0 Mostly Cobbles and boulders with coorly graded sandy gravel Much rock to rock Contact. No visible ice-GP 155.2 2.8 i 100+ 1/2 100 €3 49 poorly bonded. NP Grayish brown, with much reddish brown moteling, silty, poorly graded, sandy gravel Also a small amount of organic matter. Many barely visible ice crystals -very CP-CM 6.6 100 138.5 11/2" 1 9/ €8 IX firmly bonded. 6.0 SP-SM 212" 1 92 Same as "G", but silty gravelly sand. 138.1 70 5.6 89 IX GM Cuttings are light gray mostly med sand to silt with a few coarse chips-max size = 12". Silty sandy 2.6 or gravel or sity gravelly sand with cobbles No visible 5M Completed

Metcalf & Eddy and Alfred Hopkins & Associates Project Blue Jay

1953 Permafrost Investigation

						LA	BORA	TORY		TEST		DATA			
	Density	M C	Comp	Mox				PERC	ENT	FI	VER				,
	Da./cu ff	%	%	Size	112	3.	3	Na 4	Na 10	Nc. 20	No.40	NG -0G	Nc.200	.02 mm.	المنا
ravel e of	153.5	3.0	100+.	2"	94	7/	50	39	3C	2/	14	8	: : 5	2	
ice, J.	147.7	3.9	/00 +	2"	95	7/	47	36	29	!	14.	: : :	. 3	:	:
	150.2	2.9	100+	2"	76	51	30	28	32	16	" //	4	2	•	
ew Ite	155.9	2.5	100+	2"	94	67	! { 47 !	34 F	24	17	//	: • 4	2		
nony wet:	/53.9	2.7	100+	Z	94	65	44	32	23	; /6 :		5	3		
sèndy ce -	155.2	2.8	100+	11/2"	100	: : 63 !	49	142	33	24	· <i>13</i>		2		
, silty, of very	138.5	6.6		11/2"	100	9/	68	55	46	36	: 28	· · /8	12	. 6	٠.
	138./	5.6		2 1/2"	92	80	70	62	55	: 4 5	34	: /7	/ 2		
silt andy isible		2.6			Continue Conquest of the Continue of the Conti		2 8 8 9				; ; ;	•	:		
										1	i : :			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
		:	:				- Age age - ag				:		! !	!	
					and the second s			K							

PLATE A23

Date. DH 3-27-53: TF 4-4-53 (c4-5-53 gation Submitted by: 5.8. ST DATA Source 9 Remorks FINER Spe: In ٤ _ Materia: 0 No 40 No 00 No 200 02 mm SHOW TY Frozen chunk from test pit-No. River "H" Terrace Same - max size = 10" "H" Terrace Same - mar. size = 8" 11 - mar size = 8" Same - max. size = 1.5' "H" Terrace H"Terrace Same - max. Size = 1.5' : 28 Local Borrow Same - Scattered cobbles and boulders 18 12 34 17 12 Local Borrow Same - Test pit completed at 86'. Local Borrow pie Rig bouncing bedly due to cobbles. Hole completed at 9.0'.

ರಾ ಸಂಪರ್ಧನ್ನು ನಿರುವ ಸಹಾಭವೆಯೇ ಕೊಂಡು ಕಾರ್ಯಕ್ಷೆಯೆ ಮೊದಲು ಅಂತಿ ಸರ್ವಾಗಿ

Hole No. TTB! Location South Loop Taxiway, Sca. 36+00, 18.75'Lt. & Lab. Sample No. 24-5

1953 Per

_	02.5	ample No. 2	4-5						33 1	
	5 t								LA	80
	00	Graphic Log	Description & Classification	Density Rose /cu. ft.	M C. %	Corns.	Max. Size	14	*	
1			Asphalt Pavement							
	04'- A. 1.0-	GW NP	Gray, well graded, minus 272", crushed gravel base course. No visible ice, but some hoar-frest on the underside of some of the gravel-peorly bonded.	154.8	2.4	100+	2"	94	67	4.
	B 20'-	GP NP	Grayish brown, poorly graded sandy gravel with Cobbles No visible ice, but hoar-frost on the Underside of some of the gravel-poorly bonded.	157.2	1.8	100+	2"	88	65	5
	C 3.02	9. 6. GW	Grayish brown, well graded, sandy gravel with CODDIES. No visible ice, but hoar-frost on the underside of some of the gravel-poorly bonded.	150.7	3.2	100+	2"	81	6/	4
	D	o GW NX-IC	Same 33 °C", a few balely visible ice crystals and a thin film of ice around some of the gravel.	/50. 3	3.2	100+	2"	84	64	4
	E 5.0'-	GP IX	Grayish brown, poorly graded, sandy gravel with many cobbles. Very beny with some rock to rock contact. A few Smulf ice crystals and hoar-frost on some of the gravei	162.2	2./	100+	2"	91	83	44
	F 5.9-	SM NP	Cabbles and boulders chaked with silty gravely sand. About 1876 is +2". Much rock to rock contact. No visible ice - poorly bonued.	136 5	6 5°		2-	93	81	7.
	G 6.8-	SM- S (Grayish brown, silty gravelly sand with scattered cobbles and boulders. Some barely visible ice crystals and hoar-frest around the gravel- well bended.	/43,6	4.6		2	94	86	75
	Н	IX	Same as "G", Color is darker and slightly roddish.	142.9	4.6		2	32	84	7-
	-8.0 ل -'ه.و-	SM or GM	Cuttings are light brownish gray, mostly med sand to silt with some coarse chips - mar size = ½". No visiole ICE. Silty gravelly sand or silty sandy gravel with scattered coables.		2.8				: ! !	
		Completed			-					
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						4			:	
			\sim					*		
					1	1		1		

Project Blue Jay

1953 Permafrost Investigation

						LA	BORA	TORY		TEST	· ·	DATA			~			
	Density	M C.	Comp	Max.				PERC	ENT	Fil	ER		,		· .			S
	De /cuff	%	%	Size	12	<u>7</u>	3,	No 4	No.10	No.20	No.40	No IOO	No.200	02 mm.	LL	ρ	۶.	1 0
¢e	154.8	2.4	100+	2"	94	67	19	39	28	13	12	ۍ	2					2
	157.2	1.8	100+	z **	88	65	50	40	30	20	/3	5	3			•	•	
ķ.	150.7	3,2	100+	2"	81	SI	14	34	26	20	/3	5	3		<i>i</i> 1 : !			2
1	150.9	3.2	100+	2"	84	64	46	36	28	21	/3	5				P		:
	162.2	2.1	100+	2"	91	83	11	36	30	23	14	1	2		* * * * * * * * * * * * * * * * * * *			
	136 5	65		2"	93	81	73	64	5-5	 47 	38	24	/6	9	/5 ⁻	. nen ,	pl ast ic.	
	143.6	4.6		2	94	· 86	75	: 68	59	51	13	30 :	21	//	18	/ 3	ح	
	142.9	4.6		2	92	84 i	74	66	61	53	47	34	23	12	16	10	6	2.
		2.8			er, destallingen salan salan salan san san san san san san san san san s													

stigation

Date: DH 3-27-53: TP 4-5-53 to 4-7-53 Submitted by S.B.

TEST		DATA						- A	Source	
FIR	ER							Specific	of	Remarks
No. 20	No.40	No.IOO	No.200	.02 mm.	LL	P	P :	Grav-ty	Material	
19	,2	ح	2					2.70	Mo. River	Frozen chunk from test pit.
20	/3	Ş	3				• •	,	"H" Terrace	Same - max size cobble = 12"
20	/3	5	3					2.7/	"H"Tz/rece	Same:-Mex. Size = 8"
21	13	5	3	-					'H" Terroce	Same-max. size = 8"
23	14	4	Z						"H" Terrace	Same - max. size =12"
47	38	24	16	و	<i>15</i>	nen,	p/astic		"H" Terrace	Same - max. Size = 1.7'. Sample is not representative. Material is very frictle and difficult to obtain frozen chunk
51	43	30	21	"	. /8	/3	5		Local Borrow	Sume - mar. Size = 1.5"
53	47	34	23	12	16	10	6	2.69	Local Borrow	Same-mar size=1.5'. Test pit com- pieted at 8,0'
					·				Local Borrow	Cuttings from tri-cone rotory rock bit. Rig bouncing due to combies.
							[]			Hole completed at 9.0'.
	1					:		•		
	1			Auditore alle vi agri i canale		• •		•		
			<u>}</u>				•			
				!			i i	\Box		

PLATE A24

Metcalf & Eddy and

icle No. TTB 2 Location South Loop Taxiway, Sta. 96 too, 18.75' Rt. & Lab. Somple No. 25-5

1953 Perme

S É							110		LA	BORA
100	Graph	ic Log	Description & Classification	Density	MC	Comp.	Max			
*				iba /cu ft/	%	%	Size	i Ş	3"	3.
-03'	O: '		Asphalt Pavemer.t							
A -10'-	00	CW	Cuttings are gray, well graded sand-max size */z". Minus 212, Crushed, well graded, gravel hase course.		3.9					
B -3.0'	0 0 0 0		Cutting & Size light brownish gray, mostly med and fine Sand-max size = 1/8". No visible ice. Clean sandy gravel with comples.		3.7					
	0	C	Same as "B".		0.4					
P	Ď.		Same as 'B" but more coarse cuttings. Mostly cobbies.		2.3				ļ	
E .		CM NW	Gray silty sandy gravel with cobbles. No visible	139.9	4.5		2"	80	65	54
F		CM or SM	Cuttings are light gray, mostly fine sand and silt - max size = 40". No visible ice. Silty sandy gravel or silty gravally sand with Scattered cobbles.		2.4					
<i>y.</i>	Com	Pleted								

Project Blue Jay

1953 Permofrost Investigation

-	Density M C Comp. Max PERCENT FINER																
	Density	MC	Comp	Mas				PER	ENT			*****		y		s :	۲
	iba /cu ft/	%	%	Size	iţ	¥.),),	Na 4	Na IO	No 20	Na.40	ML 100	No.200	02年年.	LL		. د
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Date: DH 3-27-55 Submitted by: S. B.

THE RESIDENCE OF THE PROPERTY

									300 miles by 5. B.
T	DATA							Source	
NER					T	τ	r-;	0,6	Remarks
	Jan. 199	1		LL	ے ء	່ ວຸ.	Spec *<	Material	
70 40	No :00	i No.200	OSWW-				Grevity.	10,10,101	
	1				•				
	1	3		l i	•		•		_
!	1	· .			:		:	No. River	Cuttings from tri-cone rotary went hit.
į	Ì	<u> </u>		ł '	÷		•		
				!	:	:	•	<u> </u>	
	į							"H" Terrace	Same - tig Rouncing due to commes.
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:	•	i		; ;	•			"H" Terrace	Some - rig bouncing.
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		9					· H		
24	. 13		· 3				Ÿ	Local Borrow	Core Ladiy broken - 50 % recovery.
			ŧ	ì	•			1	
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	:			•				Local Borraw	Cuttinus from core bit Ria touncina
			•			٠			Cuttings from core tit. Rig touncing
		•							Madar N. Aland Alan Mara 16 Tra
			:	:		•			Material placed same time as TTB! Should be same
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									PLATE A2

Hole No. Location T.P. 3-4 [Hand Dugs RUNWAY STATION 34+06 \$

Leb. Sample No. 41-5 LAE & Graphic Log Description & Classification Denetty M C. Come Mos % 恃 Markey M. Size Bituminous Congrate Penetrotion Masadom Light brown gray, well graded, crushed, 2/2" minus, sandy gravel. No visible ice. Light brown gray, well graded, gravelly eand. No visible ice. 2-2 GW-NP 87 AA 156.9 2.3 100r CH-NF 1.3 Dark brown gray, pearly graded, sitty grarelly sand Slightly organic Few small ice crystals. AB 3P-IX 101.0 4.6 1001 95 87 Dark brown gray, poerly graded, sendy gravel with slight organic content. Many very small ico crystals. GP 2. :00 t 150.6 3. 2 90 86 IX Michies of dork gray brown, sondy gravel and a poorly graded sond of the same crist. Com-biharin gives sit; gravelly sond poorly graded. Very little visible ice. SP. SM NW 152.9 100+ 95 87 4.3 3.9 . Diorite quarry -ock 125% by solume surrounded by poorly graded sity, gravelly diarite sond. No SP-SM'R NP AE 3.7 76 45 sister to a second the rock is opproximately so fe by rolume, there is more gravel in the surrounding meterial and ice crystals appear. GP_R 151.0 1001 6.2 61 -5.3 SP Same as AE, except noible ice forms of proximately As to by volume of sand in the form of cristols
and dearing of stones. Rock 60% by volume off rox.

Mixture of AG and Att.

Medium groy brown; sitty and clayer gravely sand.
Some small ice crystals and lenses he about 10% by
volume. Slight argonic content.
Some as AH but with no ice lenses. AG IX-SC 147.8 6.5 99.2 88 2" 72 SM-SC 1/2 1246 12.0 100 84 [X-[S 7.0 3PSM 21 90 141.0 78 6.4 IX Medium brown gray, poorly graded, silly gravelly sand. For small is crystals. SPSM 80 148.5 4.4 1/2 100 IX 8.5 Gray brown silty gravelly send. Ise coals the gravel particles and there are many small ice crystels. Some organic content. SM 2" 6.3 98 88 138.3 IX-IC Some as AL except for fow thin ice lenses. 135.9 7.6 93 SM 85 IX-II 10.0 Jame 03 AM but with larger ice lenses. About 10% ice by volume. SM 8.8 133.2 96 85 IX-II 10.5 SM Medium trawn gray, sitty grovety soud. Many ince lenses up to 14 thick. Approximately 20 % ice by volume! IX-II 117.6 94 85 15.7 - 11.5 ICE Clear ica. -Bottom of pit. 'SEP 24 1953

Project Sive Jay

1953 Permafrast Investigation

				/ L		BAUM	TORY		TES1	VER	DATA					r	<u> </u>
ety Ltt.	M C.	Corne.	More Size	1 1/2	<u>I</u>	7.	No 4	No 10	Ha.20	·	No.100	No.200	O2mm.	LL	۴٤	Pı	Grov
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0.6	s. 2	100+	2.	10	86	59	30	48	29	28	8	5				ļ i	
2.9	4.5	100+	24	95	87	77	71	60	44	30	12		3. 9				
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SI : 0	6.2	100+	۳٩	85	61	50	45	38	29	20	9.	5	2.1				2.4
17.8	6.5	99.2	2"	88	72	64	58	49	36	23	9	4			! !	† :	
															: !		
4.6	12.0		1//2	100	84	74	66	59	51	44	30	21	19	19	15	4	
1.0	6.4		20	90	78	65	56	50	41	31	18	#	6.1			İ	
9.5	4.4		1/2	100	80	67	62	56	45	34	18	//	7.0		•	1	
B. 3	6.3		2"	98	88	80	72	66	57	48	33	26	11.0	15	15	2	2.0
5.9	7.6		2"	95	85	75	67	61	54	48	95	27	14	16	14	2	
			- "														
s. 2	8.8		" 9	96	85	76	67	61	56	50	37	30	19	17	14	9	
7.6	15.7		2.	94	85	76	68	61	54	45	29	21	9	14	14	0	
															•		
							,			•							
						14	†										

Hopkins & Associates

Jay nvestigation

O Continue

Sheet i of /

PLATE A26

Date:

April 7, 1953

Submitted by: M.M.C.

	TEST		DATA					· ·		Source	
T	FIN	ES							Specific	of	Remarks
10	No.2:J	No.40	No Ou	m. 200	OZ mm.	LL	PL	PI	Gravity	Material	
7	19	12	5	g					£ 78	So. Per Deila.	Impossible to separate these two little. Freeze church sample.
1	43	20	9	*					479	No. Mt.	Frozen chunk semple.
,	33	23	8	5					2.79	No River	Frozen chunk popule. Cobbles. max.
0	44	30	12	9	3. 9					No. Mt.	Frosen chunk sample. Few cobbles, maximum 2180 8".
þ	50	27	10	5				!		No. Mt.	prozen chunk could met be of how and due to triability of the material
1	29	20	•	5	2.1	} }		!	2.68	No. Mt.	Frezen chunk sample.
9	36	29	9	4			1	: :		No. Mt.	Frozen chunk comple.
9	31	44	30	21	13	19	15	4		Local Borrow	Transition zone, fill and local borrow miscal. Frozen chunk compto. Scattered cobbits, maximum size 8.
þ	41	31	18	11	6.1					Local Barrow	Many coldes meninum size 1.5! From
6	45	34	18	//	7.0	! !				Local Borrow	Frozen chunk sample. Softered cobbles, maximum 5180 2.
4	57	46	33	26	11.0	15	.13	2	2.01	Notive Soil	From chunk sample. Scattered cobbles, maximum size 8".
	54	48	95	27	14.	16	14	وم		Notive Sal	Same.
1	56	50	37	30	19	17	14	g		Native Soil	Frozen shunk somple; wany cobbles,
	54	45	29	21	9	14	14	0		Native Soil	Frozen chunk somple. Jock hammer blede driven to 128' and was shill in ice.
			1.	1					1		

Hate No.

T.F. 5-6 [Hand Day]
PUNWAY, STATION 58+06.5 50'24 & 39-5

Lab Samole No. 39

1953

Lo	b. S	emple No. 3	9-5					13	33
2	pth								Ĺ
1	å	Graphic Log	Description & Classification	Density	M.C.	Comp	Mos.		
3	•			Bas Acus M.	%	%	Size	14	1 1
La	ブー	y and an and a	Bitiminous Concrete					-	
1	<i>'</i> –	144444	Penetration Mocadom						
A	1 i-	GP NP	Light brown grey, poorly graded, crushed.	157.9	30	100r	24	76	47
1 .	8	GA GM NP	Medium gray brown, pocrty graded, silty sandy gravel. No visible ica.	144.8	4.2	9\$5	e ⁿ	86	64
A		GRGM IC-IX	Medium brown poorly graded, silty sandy gravel with cobbies to I diameter A few small ice crystals and a thin ice film on the grovel particles.	149, 3	3.2	100+	2.	87	69
A	D	SP IGIX		143.4	4.9	100+	e"	98	85
5.		GRGM 13.1 C	Sondy gravel. Many small see lenses and Crystols, with an ice film around the particles.	139.9	6.7	96.5	2"	92	79
-5.	7'-	SM	Silty gravely sand suspended in ice. Ice 1954 suy roume. Same as AF.	44.8	95.0		2"	9/	85
1 7.		ICE	Leno of clear ice.						
7	s-	IN ROCK	Broken and weathered bedrock with ice filling the fissures.						
		4 2	- Bettem of pit.						
							×		
			MED 34 1953					,	

Metcalf & Eddy and Alfred Hopkins & Associates Project Blue Jay 1953 Permetrost Investigation

				William	•	LA	BORA	TORY		TEST	ſ	DATA			- Alexandria		
	Consdy	M.C.	Come	Mex.				PER	FNT	FII	VER						
	da fou fl	%	%	Size	14	*	\$.	No 4	No. 10	No 20	No.40	N6 (OC	No.200	.02 mm	LL	Э р	Р
														:		•	
	157.9	20	100+	2"	76	47	34	26	19	19	9	5	•		!		
145	144.8	4.2	99.5	"ج	86	64	52	44	38	32	24	12	6	3.4	† †	:	
ž.												•		2 8 8 1 2 3	*		:
	149.3	3.2	100+	وم	87	69	57	47	40	33	25	13	7	2.1	•	1 1	
2/2	43.4	4.9	100+	2"	98	85	70	58	47	34	22	: 9	4	: : :	\$		• •
ez.	139.9	6.7	96.5	"مح	92	79	62	51	42	31	20	12	6	3. 3	:		! !
	44.8	95.0		2"	9/	85	75	66	59	51	42	26	19	10.6	16	15	
						3		R									

is & Associates

ation

Submitted by M.M.C.

No. 40 No. CC No. 200 OZmm	T D	Source						DATA	7
No.40 No.CC No.200 12 mm LL P - P	NER	of Remorks						•	NER
So.Ri.Della Frezen Chunk som 24	No.40 N	P	9 !	P _	LL	02 mm	No.200	No ICC	No.40
24 12 6 3.4 2.6 Unknown Same Area 43 Same No. River Same No. River Same 20 12 6 3.3 2.79 Area 43 or H-Tarroca Same Notive Soil Same No sample taken. No sample taken.				1					
Area 43 Same No. River Same No. River Same 20 12 6 3.3 2.73 Area 45 or H-Tarrace Same No sample taken. No sample taken.	9	So. Riv. Delta Frezen Chunk sample.					٠	5	. 9
22 9 4 No. River Same	24	268 Unknown Same		: :		3.4	6	12	24
20 12 6 3.3 2 2.79 Area 43 or H-Terroce Some 42 26 19 10.6 16 15 1 Native Soil Same No sample taken. No sample taken.	25	Arag 45 Same				2.1	7	13	25
42 26 19 10.6 16 15 1 Native Soil Same No sample taken. No sample taken.	22	No. River Same		:		:	4	9	22
No sample taken.	20	2.73 Area 45 or Nome Some	4	! }	•	3.3	6	12	20
	42	No sample taken.		15	16	10.6	19	26	42

TR 7-8 { Hand Dig}
RENWAY, STATION 69+05.5, 50'L+ &

LOAS	emple No. 3?	!-3					B	33 H
3 5								LAI
90	Graphic Log	Description & Classification	Density	M C.	Comp	Mes.		
*	.A.		BE /Ou it.	%	*	Size	15	3
AA	GP NP	Bituminous Concrete Povement Light brown gray, 2% minus crushed gravel base. No visible ice.	155.7	2.7	100+	dhe*	87	68
AB -2.2-	10/0/	Medium gray brown silty gravelly sand poerly graded: Thin film of ice coats particles of gravel. Some trast crystels present.	138.5	6.1	96.4	2*	96	80
AC 27-	SP	Medium gray brown, poorly graded ditty greelly sand. Thin film of ice coats stone.	/42.3	3.8	100+	" نے	87	76
AD	R W P	Diorite guarry rock makes 75 to 90% of this sample by volume. Between boulders is a dark gray sandy gravel of giarite. No visible ice. Voids of sizes up to 6" in haight noted between pieces of rock.		4.4		9"	87	63
5.7- A 5.0-	0 P- GM 11-1C		117.2	16.0		2"	78	69
AF	GM II-IC	Medium gray brown silty sandy gravely lee 20%. by volume in clear irregular lenses and messes.	.1	428		. "ع	9/	76
AG	SA1	Medium gray brown silty gravelly sand les is 30 % by volume, clear, and in form of many small porollel lenses up to 1/4" thick and a few messes eround stanes.	68.0	30.5		2"	95	81
AH -9.0-	SM I SIC	Medium brown silty gravelly sond. Some ice condition as AG.	83.4	35.2		2.	97	93
AJ AK	GM IS-II GM IS-IC	Same as AK. Medium brown sithy sandy gravel. Same ica condition as AG.	88.5	31.4		2"	78	70
AL	SM-SC ZZZ IS-IC	Gray brown sitty and clayer gravelly sand. Ice is 50% of total volume and is in parallel lenses close together. Meximum thickness 116", Bettom of bit \$24 1953	45.7	9/.8		12	100	86

Project Blue Jay. 1953 Permafrost Investigation

		بهدي زاندي عالم				LA	BORA	TORY		TEST		DATA				<u> </u>	
	Density	MC	Comp	Mex.				PER	ENT	FIR	ER		11				
	be touff.	*	%	Srze	14	2,	£	Na 4	Na iO	Na.20	No.40	No.100	No.200	.02 mm.	L.L.	PL	P
/	153.7	2.7	100+	a n	87	68	50	40	30	20.	12	8	3		·		
perly	138.4	6.1	96.4	2*	96	80	66	57	51	49	53	17	9	4			
re relly	/42.3	3.8	100±	2"	87	76	64	54	44	34	22	7	9				
Te Siens No		4.4		9"	87	63	46	36	29	21.	13	s	3		Allien eine steine der eine Anders der eine Steine eine Steine der		Andrews of the second of the s
andy s	117.2	16.0		2"	78	69	57	44	38	29	22	13	"	0			
20%	74.9	42.8		. "في	91	76	68	50	32	44	38	29	24	14	16	13	3
ce	68.0	30.5		2"	95	81	72	62	35	47	41	30	24	1,5	/7	13	4
/c e	83.4	35.2		2-	97	93	81	73	65	58	49	34	26	15	17	14	3
)cđ	88.5	3). 4		2"	78	70	61	56	50	44	37	21	15	8		Tellman sympo profilming disputations estimate	
Yel	45.7	9/-8		14"	100	86	77	68	61	52	45	33	26	14	17	12	3

ikins & Associates

PLATE A28

Onte:

APPAL 15,1953

Submitted by: M.M.C

					-	-				
ES1		DATA							Source	
FI	ER							Specific	of	Remarks
20	No.40	Na 100	No.200	.02 mm.	LL.	PL	PI	Gravity	Material	
0.	12	8	3						So Riv Delle	Frosen chunk sample.
e 9 .	33	17	9	A	·		•			Jame
14	22	7	9						No. River	S ame
	13	s	9						"F" Querry "B" Quarry	<i>POCK. It is dry trough and lanse</i>
9	22	13	"	0					Native Soil	Frozen chunk: wante.
4	<i>5</i> a	29	24	14	16	13	9		Notive Soil	Frozen chunk semple
7	41	30	24	15	/7	13	.4		Native Soil	Frezen chunk sample
8	49	34	26	15	17	14	3	2.68	Native Soil	Frezen chunk sample
g	37	21	15	8		The same of the sa			Native Soil	No tests. Freeen chunk somple.
	45	33	26	14	17	12	5	2.75	Notive Soil	Frozen chunk semple

Metcolf & Eddy

TTW 2 CT [Hand Dug] SOUTH LOOP TAXIMAN, STATION 94+80,19'FH. & 1953 Pe Leb. Sample No. 45-5 LAB & Graphic Log Description & Classification M C. Density Come 14 % barcu ft. % Size Bituminous Concrete. GW-GM Medium gray well graded, 2% minus, crushed gravel base. No visible ice. 3.0 100+ 153.3 NP 94 Medium gray brown, well graded, sondy gravel No nisible ice: GW 147.7 3.9 100+ NP Some as Somple B. 150.2 2.9 100+ 76 GW NP Same as Sample B except for faw small ise crystals and ice around some of the grovel particles. GW 155.9 2.5 100+ IC-IX 40 Some as Somple. D except there are no ke crystolo GW 100+ 153.9 2.7 94 IC -5.0 Medium, gray brown, poorly graded, sondy gravel with many cobbles. No visible ice GP 1/2 155.2 100 2.8 100+ NP 6.0 Medium gray brown, sitty sondy gravel. A little organic material. A few small ice crystals. Meterial poorly graded GRIGM 1/2" 138.5 6.6 100 IX Some as sample Gibut more sandy. 5.6 138.1 2" 80 92 SPSM IX8.0. Bo Hom of pit. SEP 24 1953

Hate N

Project Blue Jay
1953 Permafrost Investigation

	سمجه فتنجي			13	33 F	GLUMO	TOP	TOA	ETI OC	non						
					LA	BORA	TORY		TEST	1	DATA	2				
Density	M C.	Comp.	Max				PERC	ENT	FI	ER						
Bre /cu ff.	%	%	Site	14	F	3,	No 4	No.10	Na.20	No.40	No 100	No.200	.02 mm.	LL	Pί	Fi
	*	·					•		·							
-153.3	5.0	100+	ء جے	94	7/	50	39	30	21	14	8	5	2.4			
				1												
147.7	3.9	:00+	2"	95	7/	47	36	29	17	14	6	5				i
	s			*	-									: •	1	•
150.2	2.9	100+	ملحج	76	510	38	28	22	16	11	4	2				
															1	
															1	•
155.9	2.5	1004	2.	94	67	47	34	24	17	11	4	مے				
												!		!		•
153.9	2.7	100+	2.	94	65	44	32	23	16	//	5	٠				
					!	!				Ī	} 					; ;
155.2	2.8	100+	1/2	100	63	49	42	33	24	13	خ					
										•	į	: !		1) !
138.5	46		"بور	100	91	68	55	46	36	28	18	. 12	6			! !
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			""					, , ,				. <i></i>		•	:	<u> </u>
138.1	5.6	•	2"	92	80	70	62	35	45	34	17	12	6	:	:	! !
)				Ì			; ; ;	<u>.</u>		i !		:		
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kins & Assuciates

Sneet____of__/

Date:

April 4, 1953

Submitted by: M.M.C.

EST		DATA						`	Source	
FII	IER							Specific	- 01	Remarks
20	No.40	No iOC	No.200	.02mm.	LL	Pi	P i	Gravity	Material	
,	14	8	5	2.4		4	• •		No. River	Frazen chunk sample.
7	14	٥	٠				•		H-Terrace	Some
6	<i>"</i>	4	2				• • • • • • • • • • • • • • • • • • • •	:	H-Torroce	Some
7	"	4	2	Party of Control of Co					H-Terroce	Some Cabbles to B'moximum
کا	"	5	•						H-Terroce	Frozen chunt samble. Mony cobbles Maximum democrat 1.3'
#	13	j j	 						H-Terrace	Same
6	28	18	. 12	6		[Local Berrow	Frazen chunk zample.
5	34	17	12	6	· · · · · · · · · · · · · · · · · · ·	İ	; ;		Local Barrew	Frozen chunk sample
						,				
									0	
	1	<u></u>		<u> </u>			<u> </u>	1		PLATE A2

Metcalf & Edd

Location

TTB 10 [Hand Dug] SOUTH LOOP TAXINAY STATION 95+91,19'LH & 46-5

2 =							*************************************	L
• Dep	Graphic Log	Description & Classification	Density.	M C	Comp.	Max. Size	17,	7.
			ea /cu ii	*	-	3.54	. 5	4
4	6 GW NP	Bituminous Concrete Medium gray, well graded, 2/2" minus, crushed gravel base. No visible ice.	154.0	2.4	100+	مع	94	67
3	GP NP	Medium gray brown, poorly graded, sandy gravel. No visible ice.	157.2	1.8	100+	۳2	88	65
<i>i</i> -	GW NP	Same as sample B, occept well graded.	150.7	3.2	100+	2"	81	61
o'-) o'-	GW O'O IX-IC	Some as sample C with a few smail ica eristals.	150.9	3.2	100+	مح	84	64
-	GP IX	Medium, gray brown, boorly graded, sandy grovel with cobbles . A lew small ice crystals.	162.2	2.1	100+	م جے	91	85
-	SM NP	Medium gray brown, sitty gravelly sand with many copples. No visible ica	136.5	6.5	940	2*	93	84
9	SM-SC	cobtles	143.6	4.6		' دو	94	86
/	SM-SC IX	Same as Sample G except color is slightly reddish.	1429	4.6		2"	92	84
0 -		_Bottom of pit.						
								1
		SEF 24 1952						

Metcalf & Eddy and Alfred Hopkins & Associates Project Blue Jay

1953 Permafrost Investigation

						LA	BORA	TORY		TES1		DATA					
	Density	M C	Comp	Max.				PERC	ENT	FU	EP						
	los /cuft	%	*	Size	17	7,	3*	Na 4	Na 10	No.20	No.40	Ma 100	No.200	02 mm.	LL	PL	ρ;
	154.8	2.4	100+	مح	94	67	49	39	28	19	12	3	2				
	157.2	1.8	100+	۳ جے	88	65	50	40	30	20	19	5	3				
	150.7	9.2	100+	2"	81	<i>51</i>	44	34	26	20	13	5	g				
	150.9	g. 2	1000	مخ	84	64	46	36	28	الع	13	5	•				
	162.2	2.1	100+	2"	91	85	44	36	30	23	14	4	2		;		
	136 5	6.5	940	20	93	64	73	64	55	47	30	24	16	ġ	15	nen-	lostic
1	143.6	4.6		ر و	94	86	75	68	59	51	43	30	25	//	18	. /3	5
	1429	4.6		2-	92	84	74	3	61	53	47	34	27	12	16	10	6

kins & Associates

Sheet _ of /

Date

APRIL 5,1953

tigg	ation									Date Submitted by:	APRIL 5,1953 M.M.C.
ES1	7	DATA							Source		
-	No.40	Na.IOC	No.200	.02 mm.	L.L	PL	p ;	Specific Gravity	of Material	Rem	orks.
9	12	3	2			•			No. River	Frosen chunk .	ample.
00	19	5	9						H- Terrace	Fresen chunk	semple. Cabbles to
<i>20</i>	13	5	9					2.71	H-Terrece	Frozen shunk	somple. Cobbles to er:
7,	/3	5	•						H-Tornee	Frezen chunk	sample.
13	14	4	2						H-Termic	Frozen chun	t comple.
¥7	30	24	16	ġ	15	non-	lostic		H-Torroce	Frozen chunk cobbles, about 13 + 1" Moxi	semple with many to 75 % of motertal mum diameter is
7/	43	30	23	11	18	13	5		Local Barrow	Frosen chunk : cobbles, maxin	somple. Scattered own diameter 1.5.
13	47	34	27	12	16	10	6	2.69	Local Borrow	Same.	
					# !	!					
,	:			:		:			0	+	
		*	*************************************		• • · · · · · · · · · · · · · · · · · ·		*	•			PLATE A 30